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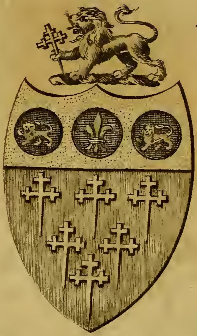

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OBSERVATIONS

ON THE

NATURE and THEORY

OF

VISION:

WITH AN

INQUIRY

INTO THE

CAUSE OF THE SINGLE APPEARANCE

OF

OBJECTS SEEN BY BOTH EYES.

By JOHN CRISP, F. R. S.

London:

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M.DCC.XCVI.

INTRODUCTORY PREFACE.

IT is probable that the human mind has never been ſubject to any illuſion more general or more forcible, than that of conceiving the objects of ſight to be external and remote, and to be perfectly diſtinct from the images which are known to be projected on the retinæ. Even perſons of ſcience, the lateſt and moſt eſteemed writers on optics, in the accounts they give of the nature of viſion, repreſent the projections on the retina as a ſet of images extremely minute and inverted with reſpect to the objects which are ſeen, and as only conſtituting a ſtep in the proceſs of viſion, or as the mean by which the external object is rendered viſible. The important diſcovery of the ſagacious KEPLER, reſpecting the ſeat of viſion, left in full force a general perſuaſion that the objects of ſight were diſtinct from the projections which he ſo fortunately brought to notice; nor has the progreſs which of late years has been made in the general ſcience of optics yet ſubdued this powerful and univerſal prejudice.

It may perhaps be ſaid, that in the ſyſtem of the human mind which generally prevails at this day, the immediate objects of perception are held to be ideas, and not the external material things themſelves. But this philoſophical notion of ideas does not reſpect viſible objects alone; it extends equally to thoſe of every other ſenſitive faculty; and in this philoſophy the idea is ſuppoſed to have ſome external object for its archetype, with which it correſponds. And it clearly appears from their writings, that philoſophers of this claſs conceive, that beſides the various viſible objects with which they are ſurrounded, there exiſts a diſtinct ſet of minute images projected on the retina: *Images of the things which they ſee.*

A DOCTRINE the reverſe of this is aſſerted in the following "OBSERVATIONS;" where it is maintained, that the projections on the retina are the immediate and ſole objects of ſight; that the viſible buildings, fields, trees, and animals, which appear around us, are not a ſet of objects ſeen *by means* of the projections, but that they are the projections themſelves. And in ſupport of this poſition the Writer does not pretend to bring forward any one ſingle fact or phenomenon that has in it the ſmalleſt degree of novelty; the proof of the aſſertion depending entirely on the circumſtances which accompany even the moſt ſimple and ordinary phenomena of viſion.

ON the miſconception now noticed, is founded a queſtion in viſion, which has much engaged the attention of optical writers; namely, " Why do objects appear " erect when the images by which they are " ſeen are inverted ?" a queſtion obviouſly implying that the thing ſeen is diſtinct from the image. And it is well worthy of remark, that another queſtion, which has been, at leaſt, equally agitated, namely, " Why do " objects appear ſingle when ſeen by both " eyes ?" is inconſiſtent with the former: there is in either of them an implication which does away the other. Thus: if, as the firſt implies, the external object is the thing ſeen, the ſecond queſtion drops; for, this being admitted, if any one ſhould aſk why objects are ſeen ſingle with two eyes, the true anſwer would be ſimply this, *becauſe they* ARE *ſingle*; for the number of images by *means* of which an object may be ſeen, cannot affect the unity of that object when ſeen.

On the other hand, if, to give ſubſtance to the latter queſtion, we admit the images to be the things ſeen, the firſt queſtion vaniſhes, ſince it implies two ſets of objects, of which the external is that ſeen: but if the image is the viſible object, there is no longer any inverſion, for the queſtion allows this to be erect.

A proposed new ſolution of the queſtion reſpecting ſingle viſion, publiſhed ſome time ſince by Dr. Wells, in a little work entitled "An Essay upon Single Vision with "two Eyes," having lately fallen into the Writer's hands, the peruſal of it occaſioned the following "Observations." The ſolution therein propoſed to the Public did not appear to the Writer to be adequate; for, even admitting the facts reſpecting viſible direction to be as ſtated by Dr. Wells, it would not thence neceſſarily follow, that objects appear ſingle *in conſequence* of ſuch a law of viſible direction.

The projections of the optic axes on the retinæ are ſingle points, and the apparent union of theſe points, which is a well-known fact in viſion, may be the conſequence of ſome original property of the eyes, or of ſome primary law of the human conſtitution; and, as ſuch, the original fact from whence the ſeeming *united direction* from the eye may be derived: and there would ſtill ariſe this queſtion: "Which "is prior in the nature of things? the "ſeeming unity of the *direction*, or the appa"rent union of the points?" or, "Which "of the two circumſtances is original, which "is derived?"

But, independent of this conſideration, certain facts may, as the Writer thinks, be produced in direct oppoſition to the propoſitions reſpecting viſible direction laid down by Dr. Wells. Theſe facts will be ſtated in the courſe of the following "OBSERVATIONS."

The ſolution of Dr. Wells, however, is ingeniouſly imagined and will probably meet the acquieſcence of many: and in proportion to this aſſent, will be the degree of its tendency to put a ſtop to the farther inveſtigation of the ſubject. On this account the Writer conceived, that to point out its defects might be of ſome ſervice to the general cauſe of ſcience, and tend to promote future reſearch reſpecting a fact, which is not yet accounted for on juſt and adequate principles.

But when the Writer came to ſtate his objections to the propoſed ſolution, he perceived, that, in order to comprehend their force, it was requiſite to entertain juſt notions of the true nature of viſion in general, and in particular with reſpect to what has been noticed in the foregoing part of this Preface. This induced him to make ſome general previous obſervations on the ſubject; and a deſire to be underſtood by thoſe who may not have been in the habit of conſidering the ſubject philoſophically, has lain him under the neceſſity of repeating many things that have been ſaid by other writers, and are well known to ſuch as have made optics their ſtudy; and which therefore may, perhaps, to ſuch, render the firſt Sections of the following "OBSERVATIONS" tedious and unintereſting. However, he truſts, that even in this part ſome few obſervations may be found interſperſed, which are either in ſome degree new in themſelves, or in the mode of their application. What is objected to the theory of Dr. Wells will be found in the Fourth and following Sections.

AFTER all, the Writer is very ready to confeſs, that the frequent occaſions he has found in the courſe of his life to correct opinions, which he had ſuppoſed to be founded on the firmeſt principles, have induced a general diffidence, and rendered him but little tenacious of any doctrine whatever:

And if, on the preſent occaſion, he ſhall be found in error, he will, as ſoon as it is pointed out to him, acknowledge it with as much readineſs as he now propoſes his opinion.

No. 5, Upper Fitzroy Street,
Feb. 10, 1796.

ADVERTISEMENT.

WHILE this little Work was in the preſs, the Writer, by mere accident, on looking over ſome volumes of the Monthly Review, became acquainted that a German work had been publiſhed by Mr. H. Aenæ, A. L. M. at Amſterdam, in which ſome circumſtances are mentioned, and ſome obſervations made, reſpecting the erect appearance of objects ſeen by means of inverted images, very ſimilar to what will be found in the following pages, and with a like intention of refuting the opinion of Dr. Reid on this ſubject. Of this work, the Writer, even now, knows nothing more than what is inſerted in the Review. But had the circumſtance come to his knowledge before the ſheet was*

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* APPENDIX to Monthly Review (New Series), Vol. VII. 1792, Art. 13, p. 539.

printed off, he certainly would either have omitted what he has ſaid, or would have differently modified it, with mention of the German work here noticed. As it is, nothing remains for him but to inſert this Advertiſement; and after all, ſuch coincidences of opinion, where there has been no previous communication, are in themſelves circumſtances really worthy of notice, and generally form a ſtrong preſumptive proof of the validity of the reaſoning.

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OBSERVATIONS,

&c.

SECTION I.

General Obſervations.—The Difficulty of diſtinguiſhing Notions founded on Experience and an acquired Habit of judging, from ſimple and original Perceptions by Sight.—Examples.—The Proceſs of Viſion erroneouſly ſtated by optical Writers.

THE bulk of mankind are little aware of how complex a nature is the operation of viſion, or how many powers of the mind are concerned in the formation of thoſe notions or perceptions which they are accuſtomed to conſider as the ſimple operation of one ſenſitive faculty. The perception of viſible extenſion, with its various modifications, of figure, poſition, and motion, neceſſarily reſults from the ſenſation of colour; but this ſenſation being merely an affection of the mind, or an effect produced upon it through the medium of the optic nerves, it follows, that we have no actual perception of external objects by ſight; the notion of externality and remoteneſs, which we ſo conſtantly and uniformly annex to the objects we ſee, being founded on the habit of aſſociating the perceptions of ſight with thoſe of touch, and is ſeated partly in the judgment and partly in the imagination.

On this account the beſt optical writers have found it neceſſary to enter in ſome degree upon the philoſophy of the human intellect, in order to explain the dependence which the ideas acquired by ſight have on the other powers of the mind. But it is probable, that an unwillingneſs to mingle metaphyſical ſpeculation with demonſtrative ſcience may have prevented them from proceeding ſo far into this branch of knowledge as their ſubject really required; and hence I have had occaſion to obſerve, even in ſome of the moſt eſteemed writers on optics, ſuch a looſeneſs or inaccuracy of expreſſion in explaining certain phænomena of viſion, as muſt naturally tend to a want of preciſion in thought.

It is accuracy of diſtinction which conſtitutes the chief difference between the philoſopher and the reſt of mankind; and if we would reaſon juſtly concerning the various phænomena of viſion, and expect to arrive at juſt ſolutions, we ſhould never overlook the important diſtinction between the ſimple and original perceptions of ſight, and thoſe adſcititious notions, which, notwithſtanding their uniformity throughout the ſpecies, are ſtill the conſequence of experience, and are properly to be referred to the judgment and imagination.

But the perception of ſenſible objects commencing at the earlieſt period of human exiſtence, and the ſimple original perceptions being moſt intimately aſſociated and confounded with thoſe acquired notions whoſe origin is beyond the utmoſt ſtretch of memory, their ſeparation in the mind which contemplates them becomes a matter of much difficulty. This diſtinction, totally diſregarded by the generality of mankind, is ſometimes overlooked even by the profeſt optical writer.

A few examples may ſerve to illuſtrate my meaning, and to relieve the reader.

The ſeeming increaſe of apparent magnitude in the celeſtial bodies, for inſtance, the moon when on or near the horizon, is a phænomenon which has been noticed by all optical writers. To the ſolution which has been given of this phænomenon by Dr. Smith I have nothing to add, nor any thing to object. But it is worthy of remark, that the habit of judging reſpecting the diſtance and magnitude of terreſtrial objects extends to the celeſtial bodies, where the circumſtances on which the principle of judgment is founded have no exiſtence.

THOUGH the apparent magnitude of terreſtrial objects is perpetually varying in proportion to their diſtance from the eye, ſtill there is ſome ſort of ſtandard in the mind, perhaps indeed not very accurate, to which a reference is generally made. It is not poſſible to form a conception of a viſible object, without ſome determinate magnitude, and this magnitude will in general be that which belongs to the object in that ſituation wherein we have been moſt accuſtomed to view and conſider it; the variations of apparent magnitude, the gradations of colour, and indiſtinctneſs of outline, which influence our judgment concerning the diſtance of terreſtrial objects, are ſo many circumſtances of real alteration in the viſible object.

When we ſee two men in a horizontal direction, one at the diſtance of ten, and the other at the diſtance of an hundred yards, there is a real diminution of apparent magnitude in the latter; but there being a regular ſucceſſion of intermediate objects, all well known, and each appearing in due proportion to thoſe with which it is contiguous, we paſs over the diminiſhed magnitude, attending only to the diſtance of which it is a ſign. But if a man ſhould be ſeen at the ſame diſtance in an elevated ſituation, as on the top of ſome high building, the mind not being accuſtomed to judge of diſtance in that direction, and there being no ſurrounding objects of known magnitude with which to compare it, and which might ſerve as a meaſure of proportion, the viſible magnitude of the man becomes in this ſituation an object of attention, and appears diminiſhed from being compared with that imperfect ſtandard in the mind above noticed, and which is formed from the apparent magnitude of a man at a ſmall diſtance.

Again: when we look through a teleſcope, which magnifies the diameter of an object in a certain degree, we judge the object to appear nearer, but not larger; for, in this caſe, the viſible magnitude, though really increaſed by the teleſcope, yet is not ſo increaſed as to exceed the magnitude which belongs to the object at diſtances in which we have been accuſtomed to view it. The increaſed magnitude correſponds with ſome one of thoſe diſtances, and operates on the mind as a ſign of it. But if the inſtrument magnified the object to a degree beyond any at which we had been accuſtomed to ſee it, or beyond the ſtandard in the mind, we ſhould then attend to the viſible magnitude, and the object would appear not only as nearer but as larger. And this is what takes place when we look at an object through a microſcope, when the viſible magnitude being increaſed much beyond any ſtandard to which the mind can refer it, or which correſponds with any diſtance at which we had been accuſtomed to ſee it, ſuch increaſed viſible magnitude engages the attention, and we view the object as magnified, without noticing the diſtance.

I HAVE only mentioned theſe circumſtances, which are well known to thoſe who have ſtudied optics, in order to obſerve, that in ſuch inſtances there is either ſome ſtandard in the mind with which a viſible object is compared, or ſome real alteration in the viſible circumſtances by which the judgment may be influenced. But in the phænomenon of the horizontal moon every thing remains the ſame, the true magnitude is unknown to ſenſible perception, and cannot be made a ſtandard of compariſon in the mind; but this true magnitude remains unaltered. The viſible magnitude, or the ſpace the object occupies on the retina, alſo remains unchanged in all the various degrees of elevation, and the real diſtance remains the ſame, or at leaſt the variations to which it is ſubject have no influence in the matter we are conſidering. And, laſtly, we are as much accuſtomed to ſee the moon at an elevation as on the horizon.

Thus it appears, that the variable viſible magnitude which takes place with reſpect to terreſtrial objects, and which in conjunction with other circumſtances becomes the ſign of diſtance, can have no place with regard to the celeſtial object. And yet mankind invariably agree in thinking that the moon appears larger when on or near the horizon than when at an elevation; and by appearing larger, they in general mean that it is a larger object to ſight; and the manner in which ſome optical writers expreſs themſelves on this ſubject rather ſeems to countenance than to correct ſuch a notion; but the philoſopher knows that the increaſe of magnitude is neither real nor apparent: the viſible object really undergoes no alteration of magnitude in any ſituation; the angle ſubtended by the diameter, or the ſpace occupied on the retina, is the ſame throughout all degrees of elevation; and the ſeeming increaſe of the magnitude is truly the operation of a faculty very diſtinct from ſimple viſion. However, ſo difficult is it to make this diſtinction, that the philoſopher who is acquainted with the ſubject, equally with the uninformed part of mankind, while contemplating the moon upon the horizon, cannot avoid conſidering it as *appearing* of increaſed magnitude.

In the foregoing inſtance a real diſtinction is overlooked. In the next inſtance I ſhall mention there is a diſtinction made where none really exiſts: this is, in ſeeing by reflection from a mirror.

When any object is placed before a plane mirror, we ſee two ſimilar things; one by direct rays, the other by rays reflected from the mirror. Now, mankind in general attribute to one of theſe viſible objects a reality which they deny to the other; they conſider the object which they ſee by the reflected rays, or, as they expreſs it, "IN THE GLASS," as the image *of the other* which they ſee by direct rays; and the general mode of expreſſion uſed by optical writers conforms to ſuch a notion.

It is, however, certain, that the two viſible objects ſeen in ſuch a ſituation are perfectly ſimilar in their nature, and the one ſeen by direct rays has no circumſtance of externality or reality belonging to it, which can with any reaſon be denied to the other. The rays which are reflected by the mirror do not iſſue *from the other object* which is SEEN direct, but this laſt is ſeen by rays which iſſue from the ſame ſource which ſends the rays to the glaſs; and the identic rays which excite that appearance which we call the reflected image of the other might, if the glaſs were removed, paſs on ſtraight to ſome other eye, where they would form a viſible object preciſely ſimilar in every circumſtance to that ſeen without the mirror, and which is generally conſidered as the real or external object. The only difference then in the two objects is, that one is cauſed by rays which paſs in a ſtraight line to the eye, and the other by rays which, impinging on the mirror, are ſent out of their ſtraight courſe; but this circumſtance can make no real difference in the nature of the object ſeen. Here then a very important diſtinction is made where none really exiſts; for one of theſe objects is conſidered as external and real, and the other as a mere appearance.

It is not to be ſuppoſed, that optical writers can be unacquainted with theſe circumſtances, though it is very certain, that their general mode of expreſſion conforms to the vulgar opinion. But, however allowable ſuch a conformity may be in matters which relate to the ordinary intercourſe of life, it ought not to be admitted in matters of ſcience, where the particular province of the writer is, to correct the erroneous opinions of the uninſtructed part of mankind: or, if it ſhould be ſaid, that the common expreſſion of "an object and *its image*," is uſed merely for the ſake of diſtinction, this ſhould be noticed, and the true nature of the objects explained.

But the notion which of all others is moſt intimately aſſociated and confounded with the ſimple perceptions of ſight, is that of externality and remoteneſs which we annex to every thing we ſee; and ſo ſtrongly is this notion impreſſed on the minds of thoſe who have not been accuſtomed to view the ſubject in a philoſophical light, that the bare attempt to correct it renders one liable to the charge of abſurdity, and of advancing poſitions repugnant to common ſenſe.

And here we may again obſerve, that the explanation given by moſt optical writers of the ordinary proceſs of viſion conforms in expreſſion with the general opinion. We are told, that the rays of light which iſſue from every point of an external object falling on the eye are, by the laws of refraction, collected into certain correſponding points on the retina, where they form a picture of the object in an inverted poſition; which picture or image, through the action of the optic nerve, is the mean by which the external object becomes viſible: that is, they conceive two diſtinct ſets of objects; one, the external objects, which they repreſent as the things *ſeen*; the other, the inverted pictures of them on the retina, which *are not ſeen.*

AND it appears, from the manner in which theſe writers ſtate ſome queſtions relating to the phænomena of viſion, that they do not expreſs themſelves in this manner merely in conformity to general opinion, but that they really conſider the thing ſeen as ſomething very diſtinct from the projection on the retina. Thus a queſtion which has given riſe to much ſpeculation on this ſubject is, On what principle is it to be accounted for, that objects are ſeen erect by means of inverted images? The queſtion thus ſtated evidently implies, that the object ſeen is one thing, and the image on the retina another: and the ingenious Dr. Smith, who has treated the ſubject of viſion fully, and in ſome degree philoſophically, applied himſelf to calculate the magnitude of the picture on the retina of the ſmalleſt viſible object, or of what he calls a ſenſible point on the retina, which he makes to be the eighth-thouſandth part of an inch*. This is certainly ſuppoſing the picture on the retina to be ſomewhat diſtinct from, and inconceivably ſmall in proportion to, the viſible object.

But ſuch an account of viſion tends to miſlead; for the truth is, that we have no perception whatever of external objects by ſight, either mediate or immediate; the projections on the retina being the direct and ſole objects of viſion. And this poſition is advanced as a plain truth whoſe proof does not reſt on any metaphyſical ſubtlety, but which is capable of as full and clear a demonſtration from the moſt ſimple and familiar phænomena of ſight, as any propoſition throughout the whole extent of natural philoſophy. But, as a prejudice ſo general and ſo deep-rooted as is that of ſeeing external objects cannot eaſily be removed, I ſhall in the following Section ſtate ſome general principles which, when well underſtood, will aſſiſt in forming juſt notions on this ſubject.

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* Smith's Optics, Vol. I. p. 31.

SECTION II.

*An Expoſition of certain general Principles neceſſary to a right Underſtanding of the true Nature of Viſion. Fallacious Reaſoning of Dr. Reid pointed out **

ONE propoſition which we ſhould ever have in view, if we would form juſt notions on the ſubject we are treating, is, that colour has no exiſtence independent of the mind; that it is no quality exiſting externally in material ſubſtance, but an effect produced on the mind by the action of the rays of light on the organs of viſion; all the variety of colours we ſee depending on the circumſtances under which the rays act on the optic nerves.

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* THE writer publiſhed ſome "Obſervations on Single Viſion" in the European Magazine for September 1794, ſome of which are repeated in this Eſſay.

It would be ſuperfluous to enter here at large, on the proof of a poſition ſo well known, and ſo generally admitted. I ſhall, however, introduce one experiment which, though ſimple, is perfectly deciſive *.

It is a well-known fact, that if two ſubſtances perfectly dry and finely powdered, the one of a blue, the other of a yellow colour, ſhould be mixed together, the maſs would exhibit a green colour.

From this ſimple experiment ariſe the following obſervations: if the ſubſtance ſhould have been from the firſt preſented to us under this form, we ſhould have conſidered it as

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* This doctrine reſpecting colour has, however, lately been called in queſtion by Dr. Reid, of Glaſgow, and Dr. Beattie, of Aberdeen; but the fallacy of their reaſoning on this ſubject might very eaſily be pointed out. And, indeed, what kind of philoſophy can be expected from writers whoſe fundamental tenet is, "that popular perſuaſion or belief is the "ultimate teſt of truth;" or "that we believe becauſe we "cannot help it, and that what we cannot help believing is "true." See Dr. Reid's "Inquiry into the Mind on the "Principles of common ſenſe," and Dr. Beattie's Eſſay "On the Nature and Immutability of Truth."

being

being of a green colour, for the ſame reaſon that we now conſider the two as being one yellow, the other blue, the green colour has equal claim to reality and to be conſidered as a quality of the ſubſtance, with the former; but in this inſtance the two ſubſtances remain the ſame after the mixture as before; the change which takes place does not affect their nature, but reſpects only the arrangement of their individual particles, and their mutual poſition in regard to each other, while every ſingle particle remains ſeparate and diſtinct; neither is there any alteration in the nature of the rays of light which enter the eye after the mixture of the ſubſtances: the ſame ſpecies of rays iſſue from the maſs as before the union, and each ray enters the eye alſo ſeparate and diſtinct. But in this ſituation the rays iſſuing from an individual particle of either ſubſtance do not occupy a ſenſible point on the retina, and therefore do not ſingly, excite any ſenſation, or become ſeparately viſible; but over ſuch a ſenſible point are diffuſed rays which iſſue equally both from the blue and the yellow particles; and the conſequence is, the ſenſation of a green colour; a ſenſation excited by the combined action of two ſorts of rays on one ſenſible point. But if the maſs ſhould be viewed through a lens of a proper degree of convexity, the rays iſſuing from an individual particle of either ſubſtance would in this caſe occupy a ſenſible point on the retina, and the blue and the yellow particles would be ſeen diſtinct from each other.

BUT theſe ſenſible points on the retina differ from geometrical points; for the latter have no dimenſions, and cannot be objects to ſenſe; but the former have dimenſions, or they could not be perceptible; and thus the ſenſation of colour, when excited, neceſſarily produces the perception of viſible extenſion, which is compoſed of ſuch ſenſible points. The extenſion is included in the nature of colour, ſince the two are abſolutely inſeparable in the imagination. It is impoſſible to conceive colour diſtinct from length and breadth, or to conceive viſible extenſion unaccompanied with colour; but extenſion in its nature conſiſts of parts, each of which has a certain poſition in reſpect to every other part. Poſition is pointed out by a difference of colour, which gives limits to certain portions of extenſion, and extenſion circumſcribed conſtitutes figure. Again: a continued ſucceſſive change of poſition conſtitutes motion; and thus the perception of viſible extenſion, with its various modifications, of figure, poſition, and motion, reſults from the ſenſation of colour.

IT is uſual for optical writers to ſpeak of the rays of light, as being continuous lines, and this may be commodious for the purpoſe of optical demonſtration; but we know that it is not abſolutely juſt. A ray of light conſiſts of extremely minute particles iſſuing from a body in the ſame direction, but perfectly diſtinct, and at very conſiderable diſtances from each other. The rarity of light, conſidered as a medium, has been particularly noticed by the ingenious Mr. Melville and others; and it is ſuppoſed that one individual particle may have proceeded to the diſtance of ſome thouſands of miles before another particle quits the body in the ſame direction; but ſo conſiderable is the velocity of their motion, that the interval in time is utterly imperceptible to ſenſe.

If we ſhould conceive rays of light as continuous lines extending from an object to the eye, it might ſeem to form a ſort of connection between the two, and might tend to ſtrengthen the erroneous notion of ſeeing the external thing: but if we conſider that the particles of light which ſtrike the eye and excite the ſenſation of colour, are abſolutely detached from the object, and that it is even poſſible that an object may no longer exiſt, when that light which cauſes what we call the ſight of it reaches the eye, we ſhall certainly be better prepared to admit the doctrine which I have advanced.

IN every inſtance where an object is preſented to the mind by means of ſight, it will probably be found, that judgment and imagination are concerned together with actual perception. And the true nature of viſion can never be rightly comprehended without making a proper diſtinction between theſe various operations. But to this end it is requiſite that we ſhould entertain juſt notions of the general nature of perception, as diſtinguiſhed from the other powers of the mind; for the great latitude and variety of ſignification with which this term has been uſed by different writers is utterly inconſiſtent with any idea of perſpicuity.

IT is not eaſy to define ſimple operations of the mind, but I ſhould explain my notion of perception by ſaying, that it is an effect produced on the mind, in which ſome object is *immediately preſent* to notice or apprehenſion.

In perception the object is actually preſent to the mind; knowledge may be conſidered as conſiſting of former perceptions repoſited in the memory. Thus, I know that the three angles of every plane triangle are, when taken together, equal to one hundred and eighty degrees, but when I am not thinking of triangles and their properties, I cannot be ſaid to perceive this truth. It is then only it can properly be ſaid to be perceived, when the whole demonſtration lies before the mind, and every link in the chain of reaſoning becomes an object of actual perception.

Again: the object of perception muſt be *immediately* before the mind, and this is what conſtitutes the difference between perception and judgment: the latter being a certain degree of perſuaſion or aſſent of the mind reſpecting that, which is not perceived, through the mediation or intervention of ſome evidence, or an inference from exiſtence perceived, to exiſtence unperceived. But the object of perception being actually preſent to the mind, it muſt in conſequence neceſſarily exiſt, and thus perception implying exiſtence is the baſis of all certainty *; nor can there be any falſe or erroneous perception, for it is equally contradictory that what is perceived ſhould not exiſt, or that what has no exiſtence ſhould be perceived: and all thoſe firſt principles of ſcience which are called axioms, are only ſo many ſimple actual perceptions expreſſed in general terms for the purpoſe of communication.

The ſeat of error is the judgment, or that faculty by which the mind forms concluſions reſpecting unperceived exiſtence, and all thoſe illuſions which are frequently termed fallacies of the ſenſes, are, properly ſpeaking, erroneous judgments or falſe concluſions, for the ſenſes preſent their objects to the mind agreeably to certain regular ſtated laws of nature, and therefore without fallacy; the er-

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* I am here ſpeaking of exiſtence in general, not meaning to limit the ſignification of the term to permanent exiſtence independent of the mind.

ror lying in the inferences which the mind draws from the objects preſented by one ſenſitive faculty, reſpecting the exiſtence of thoſe of another faculty: as, when ſeeing an object of a certain colour and figure, we conclude it to be an orange, but, on examination, find it to be a piece of wax or painted wood: or, as when a ſtick is ſeen with part of it lying in water; in this caſe the viſible appearance is certainly crooked, and ſo it ought to be by the laws of viſion; but if one ſhould thence conclude that the ſame ſtick would really be crooked when out of the water, we ſhould form an erroneous judgment, while the appearance would be juſt and regular.

When a ſphere is placed before the eyes we ſee only a circular figure, over which is diffuſed a certain gradation of colour, or of light and ſhade; the ſphericity or ſolidity is a conception or notion formed within the mind and aſſociated with the actual perception. But this circular figure and gradation of colour, which, from experience, excite the conception and belief of ſphericity, neither conſtitute it nor have any neceſſary connection with it; for a plane circular ſurface may be ſo coloured as to exhibit to the eye preciſely that gradation of colour which is the uſual ſign of ſphericity; and if a ſphere and a plane circular ſurface ſo coloured ſhould be at the ſame time placed before the eyes, we ſhould have no criterion whereby to diſtinguiſh the plane from the ſolid. Suppoſe then the eyes to be directed to the plane ſurface: in this ſituation the object, ſo far as mere ſight is concerned, would be preciſely the ſame as if the eyes were directed to the ſolid; but, ſince a ſolid cannot be perceived where no ſuch thing exiſts, it neceſſarily follows, that ſolidity or the third dimenſion, is not perceptible by ſight; but that externality and remoteneſs, the notion of which we ſo uniformly annex to the objects we ſee, is no other than this third dimenſion: and hence it alſo follows, that diſtance in a line from the eye is no direct object of ſight.

If there does exiſt a ſet of external objects, and if the mind is endowed with a power of perceiving theſe objects, it muſt perceive them ſuch as they are; the nature of the organs of ſenſe or the mode by which the perception is conveyed to the mind can make no difference in the nature of the object when perceived. We frequently hear mention of apparent figure and of apparent magnitude, as qualities or attributes of things, which have at the ſame time a different real figure or real magnitude; but this is a very inaccurate and unphiloſophical manner of ſpeaking, for no principle can be more obvious than this, that one individual thing cannot have two different figures or different magnitudes at the ſame time. Every thing whatever poſſeſſes certain qualities which diſtinguiſh it from every other thing, which conſtitute its eſſence or cauſe it to be what it is. It is impoſſible that a thing ſhould differ from itſelf or poſſeſs at the ſame time qualities repugnant to each other. And therefore, if the external things have certain properties, and if the things perceived have other properties different from thoſe or inconſiſtent with them, it muſt follow, that the things perceived are not the external things. No reaſoning can be more plain and ſimple than this. If it ſhould be ſaid that we perceive part of an object by one faculty and part by another, it may be replied that the objects of different faculties are, in truth, different things; we poſſeſs no faculty competent to the perception of ſubſtance or the ſubſtratum of qualities and the principle of individuality is a meer work of the mind. It is impoſſible that a hard or ſoft thing; a rough or a ſmooth thing ſhould be ſeen, or that a red, a blue, or a yellow thing ſhould be felt.

EXTENDED figured objects are ſuſceptible of various relations among themſelves which are no relations with regard to the percipient; ſuch are thoſe of place and poſition. While any object preſerves its identity, it muſt if perceived, be perceived to be the ſame whatever may be its ſituation; for if this circumſtance cauſes no real alteration in the nature, magnitude or figure of the object, neither can it cauſe any in the perception of that object. Mind or a percipient principle has not itſelf any immediate relation to ſpace; for if it exiſted in place or occupied ſpace, it muſt be extended and figured *. We may ſuppoſe a cube and

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* There are, I know, many, and ſome even who are in habits of abſtract ſtudy, who find a difficulty in conceiving, that any thing whatever can exiſt without place, or who ſuppoſe that the queſtion "Where is it?" is applicable to every thing whatever. And, indeed, the notions of ſpace and extenſion are ſo deeply impreſſed on the minds of thoſe who are poſſeſſed of the faculties of ſight and touch, and the imagination is ſo much more conſtantly employed on the objects of theſe faculties than on thoſe of the reſt, as to render it a matter of difficulty to diveſt the mind of theſe notions. We need not enter on a full diſcuſſion of this queſtion here, but the following conſiderations may perhaps aſſiſt our conceptions on this ſubject.

Of the five ſenſitive faculties there are three, namely, taſte, ſmell, and hearing, whoſe objects have no relation to ſpace, and which therefore could not convey to the mind a notion of extenſion or its modes. A ſound, for inſtance, may be grave or acute, of long or ſhort duration, harmonious or diſcordant, &c. but it would be obviouſly abſurd to ſpeak of a ſound that had length, or breadth, or figure.

If we ſhould, then, ſuppoſe a being endowed with only theſe three ſenſitive faculties, but to poſſeſs the ſame intellectual powers as man, ſuch as reaſon, memory, and imagination: it is evident that ſuch a being could have no notion of ſpace or extenſion; but the variety of other notions which might ariſe from theſe faculties is conſiderable, ſuch as duration, with its modes of ſucceſſion, prior and poſterior, &c. He might alſo acquire a notion of numbers, of ſimilarity, diverſity, and a ſphere to be placed in a variety of ſituations, one with reſpect to the other, but it would be obviouſly abſurd to conſider theſe circumſtances as relations in regard to the percipient. If, for inſtance, the cube were to be removed to a diſtance from the ſphere, with what propriety could it be ſaid to be removed at the ſame time to a diſtance from the mind; or that the cube lay on one ſide of the mind and the cube on the other?

I SHALL conclude this ſection with ſome obſervations on a remarkable inſtance of falſe reaſoning in an eminent writer,* in great measure

ſity, equality, and many others; and we ſhould find that ſuch a being might have notions which come under ſeven of the ten categories, and conſequently there would be room for much exerciſe of reaſon and imagination, without any notion of extenſion and its modes. This may be ſufficient to ſhew, that the idea of ſpace is not a neceſſary idea in the mind of an intellectual being. The notion ariſes from the nature of the ſenſitive faculties, but there may exiſt beings of intellectual powers and faculties far exceeding thoſe of the human ſpecies, who, notwithſtanding, may be without thoſe faculties to which the perception of ſpace and extenſion is appropriated, and who may, therefore, be deſtitute of ſuch notions.

* DR. Thomas Reid, Profeſſor of Moral Philoſophy in the Univerſity of Glaſgow, in a work entitled, "Eſſays on "the Intellectual Powers of Man." See this Work, from Page 206 to 212.

meaſure founded on conſidering the relations which ſubſiſt among extended things, as being alſo relations in reſpect to the percipient.

I SHALL produce the paſſage, not only as it has an immediate relation to the ſubject of theſe obſervations, but becauſe it may be conſidered as a curious fact in the hiſtory of the human mind, and proves how readily an enlightened and ſtrong underſtanding may be perverted by a predilection for ſome favorite theory.

THE grand aim of this writer throughout his works is, to aboliſh the received ſyſtem concerning ideas; in oppoſition to which he maintains, that the mind is endowed with a power of perceiving external objects *immediately*; ſenſation being, in this writer's theory, only a ſign paſſing rapidly and almoſt imperceptibly through the mind, ſuggeſting, by ſome law of nature hitherto unnoticed by philoſophers, the immediate perception of the external object.

Mr. Hume, ſomewhere in his writings, ſpeaking of the general notion of the externality of the objects we perceive, ſays: "But this univerſal and primary opinion "of all men is deſtroyed by the ſlighteſt "philoſophy, which teaches us, that nothing can ever be preſent to the mind but "an image of perception, and that the ſenſes "are the only inlets through which theſe "images are received, without being ever "able to produce any immediate intercourſe "between the mind and the object. *The "table which we ſee ſeems to diminiſh as we "remove farther from it; but the real table, which exiſts independent of us, ſuffers "no alteration. It was, therefore, nothing "but its image which was preſent to the "mind.* Theſe are the obvious dictates of "reaſon;" ———— So far Mr. Hume.

This paſſage is quoted by Dr. Reid in his Eſſays on the Intellectual Powers of Man, and his reply to it is the inſtance of falſe reaſoning to which I have alluded. This writer, after having explained the difference between tangible and viſible magnitude, proceeds thus:

" The argument is this: 'the table we " ſee ſeems to diminiſh as we remove far- " ther from it;' that is, its apparent mag- " nitude is diminiſhed, 'but the real table " ſuffers no real alteration;' to wit, in its " magnitude; 'therefore, it is not the real " table we ſee.' I admit both the premiſes in " this ſyllogiſm, but I deny the concluſion. " The ſyllogiſm has what the logicians call " two middle terms; apparent magnitude is " the middle term in the firſt premiſe, real " magnitude in the ſecond. Therefore, " according to the rules of logic, the con- " cluſion is not juſtly drawn from the pre- " miſes. But, laying aſide the rules of

" logic,

" logic, let us examine it by the light of
" common ſenſe.

" Let us ſuppoſe, for a moment, that it
" is the real table we ſee; muſt not this
" real table ſeem to diminiſh as we remove
" farther from it? It is demonſtrable that
" it muſt. How then can this apparent di-
" minution be an argument that it is not
" the real table? When that which muſt
" happen to the real table as we remove
" farther from it does actually happen to
" the table we ſee, it is abſurd to conclude
" from this, that it is not the real table we
" ſee. It is evident, therefore, that this in-
" genious author has impoſed upon himſelf
" by confounding real magnitude with ap-
" parent magnitude, and that his argument
" is a mere SOPHISM.

" I OBSERVED, that Mr. Hume's argu-
" ment not only has no ſtrength to ſupport
" his concluſion, but that it leads to the

" contrary concluſion; to wit, that it is the
" real table we ſee; for this plain reaſon,
" that the table we ſee has preciſely that
" apparent magnitude which it is demon-
" ſtrable the real table muſt have when
" placed at that diſtance."

Such is Dr. Reid's reaſoning in oppoſition to Mr. Hume's ſyllogiſm; in which it is ſurely the former who has impoſed upon himſelf, and the ſophiſm may be fairly retorted upon him.

That a perſon, endowed with talents ſo reſpectable as are thoſe of Dr. Reid, ſhould ſuffer himſelf to be deluded by ſo obvious and palpable a fallacy is indeed a memorable inſtance of the weakneſs of human reaſon. The whole train of argument here adduced; this ſuppoſed detection of a ſophiſm in the plain and ſimple propoſition of Mr. Hume, does itſelf conſiſt of a ſtring of ſophiſms and erroneous notions from beginning to end.

FIRST: the author conceives the diſtance of the table to be a relation with reſpect to the percipient; he ſuppoſes it to be carried away from the mind when it is removed to a diſtance from the body; a mere prejudice of untutored minds, but a notion very unworthy of one accuſtomed to view ſubjects in the light of philoſophy. While an object remains unchanged in its own nature, the perception of that object, if the mind really has the power of perceiving it, muſt alſo remain unchanged.

IN the next place, there is an obvious fallacy running through the whole argument, implying the exiſtence of the very thing it denies; that is, of a viſible object diſtinct from the real or external object, and ſubject to certain laws of variation utterly inconſiſtent with the nature of the latter.

AGAIN: the author ſeems to be led away by the mere ordinary conſtruction of language, conſidering the term apparent as a quality or accident of which magnitude is the ſubject; but this term, though predicated of magnitude, obviouſly relates to the percipient. Magnitude is only ſuſceptible of more or leſs, and the external table, with all its attributes, remains preciſely the ſame, whether it be apparent or not apparent.

WHAT Dr. Reid calls the two middle terms, real or fixed magnitude, and apparent or variable magnitude, are inconſiſtent qualities which cannot exiſt at the ſame time in the ſame ſubject. Dr. Berkeley, from whom Dr. Reid ſeems to have taken up his notions of viſible and tangible magnitude, plainly perceived this, and he conſequently maintains that there is no common object of ſight and of touch. But Dr. Reid, allowing the premiſes and rejecting the concluſion, admits the abſurdity that the ſame body may have at the ſame time two different magnitudes. Mr. Hume's argument may be ſtated thus:

The external table has a determinate, invariable magnitude;
The object ſeen has a variable magnitude;
But theſe two qualities cannot ſubſiſt at the ſame time in the ſame ſubject:
Therefore, the external table is not the object ſeen.

I CANNOT conceive ſounder logic than this is; and the ſophiſtry is to be found in Dr. Reid's reaſoning, which attributes to the ſame ſubject repugnant and inconſiſtent qualities.

THE author ſays, "If we ſuppoſe, for a "moment, that it is the real table we ſee, "it is demonſtrable that it muſt ſeem to "diminiſh as we remove farther from it." &c.

I COULD wiſh the writer had attempted this demonſtration of which he ſpeaks; the event might have led him to a perception of his error. While we remove to various diſtances, the table certainly remains preciſely the ſame; neither it nor any of its attributes ſuffer any alteration, whether it be ſeen or not ſeen. The ſeeming diminution is not any affection of the external table, but of the projection on the retina; and though it may be demonſtrated, that the angles made by lines drawn from a point to the extremities of a figure, muſt diminiſh, as the figure is farther removed from the point from which the lines are drawn; yet this is not by any means a demonſtration that a mind endowed with the power of perceiving external objects which have a fixed magnitude, muſt perceive theſe objects as having a magnitude proportionate to ſuch angles.

THIS may conſtitute a law *of viſion* in beings framed as we are, but it can be no law of general percipiency; on the contrary it leads directly to this concluſion, that the faculty of ſight is not a power of perceiving external material objects; ſince objects perceived by viſion have, in conſequence of this law, certain qualities and are ſubject to accidents, which cannot be predicated of external objects exiſting independent of the mind.

AGAIN: the writer ſays, "when that "which muſt happen to the real table as we "remove farther from it does actually hap"pen to the table we ſee, it is abſurd to "conclude from this, that it is not the "real table we ſee." But I would aſk of Dr. Reid, what in this caſe does happen to the real table by our being farther removed from it? Surely nothing at all. The diminution which Dr. Reid calls ſeeming, is not ſeeming, but real; it is no affection of the real table, which remains the ſame in all circumſtances of diſtance; but it is a real diminution of the projection or viſible object, and which this writer throughout confounds with the external object.

UPON the whole, then, it appears, that Mr. Hume's ſyllogiſm is a ſimple and evident truth, founded on this obvious propoſition, that a variable and an invariable magnitude cannot be qualities of the ſame ſubject at the ſame time; and the charge of ſophiſtry fairly returns on Dr. Reid. But even the errors of ſuch a writer afford a leſſon to the wiſeſt; they may hence learn to propoſe their opinions to the world with moderation and diffidence, leſt a ſuppoſed detection of the errors of others may ultimately appear to be only an expoſure of their own.

I HAVE dwelt at ſome length on this circumſtance, becauſe it is preciſely a caſe in point, and tends to elucidate the ſubject we are conſidering.

IT may be, however, neceſſary to obſerve here, that the theory which Dr. Reid intended to overſet by the above reaſoning, is ſomewhat very diſtinct from what has been advanced reſpecting the projections on the retina. The ſyſtem he oppoſed is that which maintains that the immediate objects of human perception are ideas. The philoſophers who embrace this doctrine may be diſtinguiſhed into two claſſes: the firſt, and much the more numerous, at the head of which we may place Mr. Locke, admit the exiſtence of the external or material object, which they conſider as the archetype with which the idea has a general conformity; and it is evident from the writings of this claſs, (among whom was Dr. Smith, who has treated ſo largely on optics) that they in general conſider the projections on the retina as being very diſtinct from the immediate objects of ſight, and as conſtituting only a ſtep in the proceſs of viſion.

The other claſs deny altogether the exiſtence of external objects, or of material ſubſtance; at the head of theſe we may conſider

ſider Dr. Berkeley and Mr. Hume, whoſe ſyſtem has met with but few followers.

The general principles which have been ſtated in the preceding part of this Section may, I hope, in ſome degree, aſſiſt in forming a juſt conception of the ſubject to be treated; but I am ſenſible there are ſtill ſome ſtrong prejudices to be ſubdued.

SECTION III.

The Projections on the Retina the immediate Objects of Viſion; no identic Objects of Sight and Touch.—Simple Experiments brought to prove the firſt Poſition.—The Queſtion of ſeeing Objects erect by inverted Images conſidered *.

I AM well aware that the account I am about to give of the proceſs of viſion may at firſt ſubject me to the charge of advancing paradoxes, or notions repugnant to common ſenſe, from thoſe who are not in the habit of conſidering the ſubject in a philoſophical light. However, I have little doubt, that a patient attention to what will be produced in ſupport of the doctrine I ſhall ſtate, will get the better of a prejudice deeply impreſſed on the mind, from a long continued habit of conceiving the object of ſight to be external and remote.

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* To the reader, who is acquainted with what has been written on the ſubject of viſion, it will readily occur that the principles advanced in the ſubſequent account nearly concur with thoſe of the ingenious Dr. Berkeley as laid down in his "New "Theory of Viſion." However the writer of theſe obſervations had formed his notions on this ſubject from his own reflections long before the works of that celebrated author had fallen into his hands, and while reſiding in a very obſcure and remote

I HAVE already ſtated in the Firſt Section the manner in which the proceſs of viſion is generally explained by optical writers; in oppoſition to which, I have advanced, that we have not by ſight any perception of external objects, and that the projections on the retina are the immediate and ſole

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remote part of the world, when he could have but a very limited acceſs to books and not any to the converſation and ſociety of men of ſcience and literature.

objects of viſion; but I ſhall ſtate this poſition at more length.

It has already been obſerved, and I ſuppoſe at this time it is in general well underſtood, that colour is nothing more than an effect produced upon the mind through the medium of the organs of viſion. The rays of light collected on the retina by their natural action on the optic nerve excite the ſenſation of colour, with the conſequent perception of extenſion; and certain portions of this extenſion being limited and marked out by a difference of colour give riſe to the perception of viſible figure; thus the ſenſation of colour renders perceptible to the mind the figures projected on the retina; and this proceſs conſtitutes viſion.

We remain in total ignorance of the real efficiency of the rays of light on the optic nerves and the brain in cauſing viſion; but when ſight is produced, there is an object immediately preſent to the mind; and the preſent queſtion is, not how this object is produced? But, what is it? Should any one chuſe to maintain, that what I call the projections on the retina are only ideas, I do not feel inclined to diſpute the point; however, we have the ſame evidence for the exiſtence of theſe projections, as we have for thoſe made on paper by a lens. If the things we ſee are only ideas, are they the ideas of external objects, or ideas of the projections on the retina? If they are more than ideas, are they the objects themſelves, or are they the projections? The general opinion is, that the projections on the retina merely conſtitute a ſtep in the proceſs of viſion, and are only the means by which the objects we ſee, whether theſe be the external things themſelves, or only the ideas of them, become viſible. That ſuch is the opinion of optical writers appears from the circumſtances mentioned in the firſt ſection; and I appeal to the experience of every individual, let him be ſkilled in optics or not, Whether, whilſt he contemplates the ſet of viſible objects before him, conſiſting of buildings, fields, trees, animals, &c. and paſſes his eye over parts of his own perſon, he does not conceive that there is, beſides theſe, a ſet of objects projected on the retinæ of his own eyes, in an inverted order, inconceivably minute, and perfectly diſtinct from the things which he ſees?

I AM ready to confeſs for my own part, that even now, while writing expreſſly againſt ſuch a notion, as I ſit in my room, and view the various objects around me, I can ſcarcely avoid conſidering them as being diſtinct from the projections which we know are formed on the retina. I am apt to conceive of my own eyes as being thoſe objects which I have ſeen by reflection from a mirror, and that theſe viſible eyes are the places where the projections are formed. And it is in oppoſition to a perſuaſion ſo general that I advance, that this ſet of objects which we ſee, theſe buildings, fields, trees, animals, &c. which we conceive to be external in regard to ourſelves, are really no other than the projections on the retinæ of our own eyes.

In advancing this poſition the writer does not pretend to have diſcovered any new fact in viſion; nor does the proof of this doctrine reſt on any abſtract ſubtlety, or metaphyſical refinement whatever; but on this plain conſideration, that the phænomena of viſion are utterly inconſiſtent with the fact of ſeeing external objects; but are all perfectly conformable with the projections on the retina. Some very ſimple and common phænomena will be ſelected to illuſtrate this doctrine.

But before we proceed let me obſerve, that the ſcientific or geometrical part of optics will remain entirely unaffected by the poſition now advanced. The general properties of light, the laws of its refraction, reflection, inflection, &c. will all remain as before. What is called the external object, from which the rays of light are ſuppoſed to be reflected, theſe reflected rays, and the image they form, are equally ſuppoſed in either theory. The difference lies only in this circumſtance, that the former doctrine teaches that the external object is the thing ſeen, and that the picture on the retina is only the mean by which it becomes viſible; whereas I hold, that the external object is only tangible, and that the image or projection of this tangible object is what in the proceſs of viſion becomes viſible.

It is the province of optics to unfold and to explain the various relations which theſe viſible perceptions have to the external or tangible

tangible object, and to inveſtigate and define the laws by which they are excited, and the changes they undergo from the various circumſtances of light and ſituation. The direction in which light acts, the laws by which this direction is changed, with the conſequent changes produced in the viſible figures, are the chief objects of this ſcience: all of which will remain unaffected by the poſition in queſtion. And it is worthy of remark, that the ſcience of optics is chiefly founded on notions originally derived from the ſenſe of touch. Solidity, reſiſtance, denſity or rarity of a medium, refraction, reflection, &c. are all tangible notions; and of two perſons of whom one is ſuppoſed to poſſeſs the faculty of ſight without that of touch, and the other that of touch without ſight, there can be no doubt that the blind perſon might make a much greater progreſs in comprehending the principles of optics, than the one who poſſeſſed ſight without touch.

It will, I know, be generally conceived, that the evidence of ſenſe, the moſt direct of all evidence, is againſt the poſition. Is it poſſible, it will be ſaid, to be miſtaken in a matter ſo obvious? Do we not ſee that the objects by which we are ſurrounded are without ourſelves? Can we not extend the hand and take hold of a thing, and can a thing which we hold in our hands be a picture on the bottom of the eye? Or, again: Are not the objects which we ſee incomparably larger than our whole bodies, much more than our eye, and can the houſe which we ſee, or which we inhabit, be only an image in the eye?

Prejudices ſuch as this are ſtrong and not to be readily overcome: but have we not originally had other prejudices equally deep-rooted, which however have been removed by reaſoning? Such, for inſtance, is that reſpecting the apparent magnitude of the horizontal moon: this notion may be overcome by meaſuring the angle with a proper inſtrument. Again: the apparent diurnal motion of the ſun from eaſt to weſt: here we ſeem to have the ſtrongeſt evidence of ſenſe; but reaſon in time overcomes this prejudice. And thoſe alſo ſtated above may by a little patient attention to plain reaſoning be laid aſide. They are founded on the ſuppoſition that the object of ſight is identic with that of touch, and on erroneous notions concerning the general nature of magnitude.

THERE are two modes by which the notion of extenſion and figure is originally introduced to the mind; by the ſenſe of ſight, and by that of touch *. And extenſion and figure, conſidered abſtractedly, muſt be the

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* DR. Berkeley has endeavoured, in his New Theory of Viſion, to prove, that there is no identic object of ſight and touch; however, this notion is not generally admitted even by men of ſcience, and ſome attempts have lately been made to overthrow his doctrine, though very ineffectually. If I have repeated any of Berkeley's arguments I do not apprehend it neceſſary to make a direct reference.

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ſame, by whatever mode it may become preſent to the mind; that is, length and breadth are equally length and breadth, whether accompanied by ſenſations of ſight or of touch. The eſſential properties which conſtitute a circle or a ſquare are common to thoſe figures, whether brought before the mind by one or the other of theſe faculties; and therefore the figure, conſidered geometrically, is the ſame*; but as one circle may be deſcribed on paper, and another on wood, and theſe circles, though their properties are the ſame, are not identic, ſo the extenſion and figure preſented to the mind by ſight, is not the identic extenſion and figure preſented to the mind by touch: that is, there is no object common to both faculties.

We have no difficulty in allowing that ſound cannot be the object of the ſenſe of ſmell, of ſight, or of touch; or that colour cannot be felt, or the ſenſations of touch be ſeen; but ſince extenſion and figure cannot be either perceived or conceived unaccompanied with the ſenſations either of ſight or touch, it follows, that the extenſion and figure as perceived by each muſt be peculiar to its own proper faculty; and we may with equal propriety pretend to hear ſmells, or to catch a ſound in the hand, as to touch the thing which we ſee, or to ſee the thing which we touch. The operation of each is perfectly diſtinct in its own nature, and the aſſociation is only the effect of cuſtom and experience.

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* Here Dr. Berkeley and myſelf differ ſomewhat in our notions.

WHEN an object is ſeen by reflection from a mirror, no one would think of aſſociating the tangible notions with it; for inſtance, let a perſon take up an orange in his hand, and hold it before a common looking-glaſs, and he will ſee the orange in his hand by reflection, but he will not think of affirming that the thing he feels in his hand

and the thing he ſees in the glaſs are one and the ſame. But it has been already obſerved, that the object ſeen in the glaſs and that ſeen without it are preciſely of the ſame nature, nor can there be the ſmalleſt reaſon in the nature of things for combining the ſenſations of touch with one rather than with the other, and ſince they cannot belong to both, they muſt belong to neither.

THAT the extenſion and figure perceived by touch are not identic with that perceived by ſight, alſo appears from this, that they ſeparately poſſeſs qualities which are quite diſtinct and incompatible with each other. The extenſion perceived by touch has three dimenſions; that perceived by ſight has only two. Solidity, which is a direct object of touch, is no object of ſight; on the other hand, a diſtinction of figure on a plane ſurface is no object of touch, but is a ſimple and direct object of ſight by difference of colour. Again: tangible figure and magnitude are permanent and invariable, viſible figure and magnitude infinitely mutable and fluctuating.

A PROPER conception of this circumſtance will tend to correct the above-mentioned prejudices, and enable us to form juſt notions of the general nature of magnitude, which to human minds is merely a relative quality: we have no knowledge of abſolute magnitude, and the magnitude of any object can neither be expreſſed nor conceived but by means of ſome other thing with which it is compared.

BUT as viſible magnitude and tangible magnitude are not homogeneous throughout, they are not capable of any common meaſure or ſtandard. Viſible magnitude requires a viſible meaſure, tangible magnitude a tangible meaſure: and ſince viſible magnitude is tranſient and fluctuating, while that which is tangible is permanent and invariable, we take the latter in general for a ſtandard of compariſon; and the general terms for meaſure are taken from parts of the body, the inſtruments of touch, as an inch, or the breadth of the thumb; the ſpan, or ſtretch of the hand; the length of the foot; the cubit, or fore-arm; the ell, or full ſtretch of one arm; and the fathom, or full ſtretch of both arms: all which can only be applied by touch.

It is now, I think, about two hundred years ſince the projections on the retina were firſt diſcovered by the ſagacious Kepler; and it was in making experiments on the eyes of animals that thoſe projections became known; and they are found to be ſimilar to other projections made by lenſes, and founded on the ſame optical principles. It does not, however, appear, that this diſcovery produced any change in the general perſuaſion that the objects of ſight are external and remote. The projections on the retina were conſidered, not as the things ſeen, but only as a new-diſcovered ſtep in the proceſs of viſion, and as a ſet of objects extremely minute when compared with the ſuppoſed viſible external object.

But this opinion of minuteneſs is entirely founded on a miſconception, on a compariſon of the things which are ſeen with an imaginary ſet of things which are not ſeen. The external or tangible object can have no relation in magnitude to the viſible object. If we ſhould propoſe to eſtimate on optical principles, the proportion which the magnitude of the projected image bears to that of the object, we either conceive them both as viſible, or both as tangible; in which way only they can bear any relation or proportion in magnitude to each other. But if we conſider them as they really are, the one only tangible, the other only viſible, there can be no common meaſure or ſtandard by which the relation can be eſtimated. Should any one doubt this, let him conceive two objects, the one only as viſible, the other only as tangible, and then attempt to compare them in reſpect to magnitude, and it will be found impoſſible: to ſay, that one is equal to, or greater or leſs than the other, would expreſs nothing.

The whole of viſible nature conſiſts of a ſet of objects or figures projected on the retina, which, having a juſt proportion to each other, agreeable to the laws of viſible figure, appear of their proper and juſt magnitude, which can neither meaſure nor be meaſured by any external magnitude which is no object of ſight. Our own bodies form a part of this ſet of viſible objects, and our notion of the magnitude of the eye takes its riſe from ſeeing the eyes of others, or our own eyes by reflection from a mirror; and the notion of the minuteneſs of the picture on the retina ariſes from ſeeing the projections in the eye of ſome other animal, and from comparing thoſe projections with the ſimilar objects which we ſee direct, and in reſpect to which they are extremely minute. But it ſhould be noticed, that what in this caſe the obſerver ſees are not the identic objects which the animal would ſee with the eyes in his head. The minute objects are not the original projections in the eye of the animal; but *this eye* and theſe projections are again re-projected on the eyes of the obſerver, and compared with the original projections in his own eye *. And when Dr. Smith ſet himſelf to calculate the magnitude of the picture on the retina of the ſmalleſt viſible object, it was in fact the magnitude of theſe re-projections which he was eſtimating. When, therefore, it is ſaid that an object is much larger than the eye, all that can be meant is, that it is larger than the eye which we ſee; but this eye which we ſee is only, like other viſible objects, a figure projected on the retina; and the eye, properly ſpeaking, and conſidered as the organ of viſion, cannot poſſibly become an object of ſight, nor can we form any notion of its abſolute magnitude.

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* See Berkeley's New Theory of Viſion, Article 116.

The above obſervations will, I hope, be ſufficient to remove the prejudices above ſtated; and we may now proceed to the direct evidence.

From a great variety of experiments which might be adduced to prove that the projections on the retinæ are the ſole objects of viſion, I ſhall ſelect a few which are at the ſame time extremely ſimple and perfectly deciſive.

It is a fact well known to thoſe who have ſtudied optics, that in a certain poſition of the eyes the object to which they are directed, though equally projected on each retina, appears ſingle; and it has been generally ſuppoſed, that in this caſe the projection falls on the center of each retina, or on points ſimilarly ſituated in reſpect to the centres, and theſe points have by optical writers been called correſponding points.

I SHALL ſuppoſe the correſpondence of theſe points to depend on the circumſtance of the ſingle appearance of the object projected, and not on a ſtrict geometrical ſimilarity. The fact is well eſtabliſhed; and it is alſo well known, that if by any means the ſituation of the projection on either eye ſhould be changed, the other remaining the ſame, two ſimilar objects would become viſible, or, as it is generally but very inaccurately expreſſed, the object would appear double; and as this ſingle appearance cannot be accounted for by any of the known properties of light, or general laws of refraction and projection, it has been made a queſtion, whether this effect is to be attributed to cuſtom and experience, or whether it be the conſequence of ſome original law in the human conſtitution?

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This queſtion will be conſidered hereafter: at preſent we have only to do with the fact. And it is here to be noted, that though the pictures which fall on correſponding points of the retinæ appear ſingle, the viſible object is compoſed of the two projections.

It is eaſy to conceive, that if two plane figures perfectly ſimilar and equal in magnitude ſhould be applied one over the other, the outlines of the two muſt coincide and form one figure. The effect of viewing objects through two tubes, one applied to each eye, is well known; if ſuch tubes are properly applied, and two ſimilar objects, as two guineas, placed one in the axis of each tube, the projections will fall on correſponding points of the retinæ, when the axes of the tubes and the axes of the eyes coincide, and the two guineas will be ſeen under one outline and become undiſtinguiſhable. This effect is ſimilar to what occurs in the ordinary uſe of the eyes; the two projections are ſeen under one outline, and the effect is, to render the appearance more vivid.

But if, while looking ſteadily at any object, the globe of one eye be made to move in the ſocket by means of preſſure with the finger, the ſituation of the projections on the diſtorted eye muſt be changed, and one figure will be ſeen to ſlide off as it were from the other, and two diſtinct objects perfectly ſimilar will now become viſible, the one ſituated above or below, on one ſide or the other, according to the direction in which the preſſure is made. This experiment muſt be familiar to all, and has frequently been noticed by the philoſopher; and it is to be noted, that the two objects will be equally accompanied with all thoſe acquired notions which ariſe from the ſubſtitution of viſible perceptions as ſigns of diſtance, ſolidity, and other tangible qualities.

But the circumſtance to which we are now to attend is this, that the objects we now ſee are two diſtinct things, and not one and the ſame. Writers on viſion ſay, that in this ſituation "an object appears double." But in this phraſe there is a degree of inaccuracy unworthy of ſcience and bordering on contradiction; for the article before the ſubſtantive denotes one thing, but the word double denotes two things. What then is a double object? Is it one or two objects? But let us leave words and attend to things. That the objects which in this ſituation I ſee are two diſtinct things, is a clear certainty. They are ſimilar, it is true; but ſimilarity is not identity. That they may be each excited by the ſame tangible objects I admit; but this cannot make the two things to be only one; and on this circumſtance reſts the concluſion, that the things ſeen are the projections on the retinæ. It is as impoſſible for the ſame thing to be SEEN at the ſame time in two diſtinct places, as it is that it ſhould

EXIST at the ſame time in two different places: and as the two things ſeen have each equal claim to reality and externality, they muſt be either both real or both appearances; and we can only avoid the abſurdity of ſuppoſing that external things may be made by preſſing the eye with a finger, by admitting that we ſee only the projections on the retinæ; the one is a projection on the right eye, the other a projection on the left. If we now withdraw the preſſure, the two objects will be ſeen to unite or coaleſce into one figure; in this caſe, the ſingle object is compoſed of what before appeared as two; and as they were not external while ſeparated, the mere junction under the ſame outline cannot render them ſuch.

AND the reaſoning here uſed will apply equally againſt the generally-received ſyſtem of ideas; for this theory ſuppoſes a ſet of external objects, as the archetypes to which the ideas have a perfect conformity, and

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conſequently the two viſible objects in the above caſe would require two archetypes or external objects.

THE circumſtance of ſeeing objects by reflection from a mirror, has already been conſidered in the Firſt Section as an inſtance of erroneous conception on the ſubject of viſion. This ſimple and familiar experiment may be again introduced as a proof that we ſee only the projections on the retinæ; for, as has already been obſerved, the object ſeen by reflection has equal claim to reality and externality with that ſeen direct; the two things are preciſely of the ſame nature, and ſince they cannot both be real external things, it follows that neither is; and it would be a fruitleſs attempt to aſſign any ſolid reaſon for aſcribing externality to one while it is denied to the other.

ANOTHER familiar phænomenon, utterly inconſiſtent with the fact of perceiving the external object, or any idea correſponding with ſuch an object, is, that of ſeeing through a polyhedron or multiplying-glaſs. When an object is ſeen ſingly through any tranſparent ſubſtance, as glaſs, the circumſtance is never ſuppoſed to affect the reality of the object ſeen; as no object is conceived to be leſs real and external from being ſeen through a window-glaſs.

Suppose then a glaſs with three or more plane faces cut on it; on putting this to the eye, we ſee diſtinctly as many objects as there are faces on the glaſs. I aſk then, What are theſe? They are certainly diſtinct from each other, and, though ſimilar, are not identic. They cannot ſurely be all external things; but either of them ſeen through a ſingle face of the glaſs, or unaccompanied with the reſt, would have been accounted a real external object. Their claim then to reality is equal; and ſince they cannot be all external things, it follows that

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not any of them are; the truth is, they are all equally projections on the retina.

The laſt argument I have to mention is drawn from the motion of light.

It is now ſome years ſince aſtronomers diſcovered that the particles of light had a progreſſive motion of extreme velocity, which they found means to calculate; and it has been diſcovered that light takes up about eight minutes in paſſing from the ſun to the earth; from whence it follows, that the viſible object which we call the ſun is excited by particles of light which had left the ſun eight minutes before they arrived at the eye; and the obvious conſequence is, that if the ſun ſhould be carried beyond the ſphere of human perception, or ſhould it be at once annihilated, we ſhould ſtill continue to ſee for eight minutes that object which we have been accuſtomed to conſider as the ſun; wherefore we cannot maintain that the object we ſee is really the ſun, without maintaining the abſurdity that an object may be perceived which has no exiſtence.

It would be needleſs to produce more experiments, though many immediately preſent themſelves; and I probably have already dwelt too long on a ſubject which ſome writers would have compriſed in much leſs compaſs. Every circumſtance in the above ſimple and familiar phenomena is utterly inconſiſtent with the fact of ſeeing external objects, or ideas which correſpond with them; while it is in every particular perfectly conformable with the projections; and we may therefore lay it down as an indiſputable fact in viſion, that the images projected on the retinæ are the immediate and ſole objects of the viſual faculty. Theſe are the viſible perceptions, which by habit are ſo intimately aſſociated with the objects of touch, as not to be ſeparable in the ordinary exerciſe of the underſtanding; from which aſſociation ariſes that almoſt inſurmountable perſuaſion, that the thing which we ſee and the thing which we touch are one and the ſame.

But that externality which the mind is ſo accuſtomed to conſider as relative to itſelf, is, in fact, only a relation among the viſible objects themſelves. We form a conception of the body from what we ſee; but this, equally with other viſible objects, is only a projection on the retina; and the remoteneſs or externality of an object is nothing more than its ſituation with reſpect to this *viſible part* of ourſelves.

But it will perhaps be ſaid, Since it is allowed that the theory now advanced will make no change in the demonſtrative part of the ſcience of optics, to what purpoſe is it brought forward, and what advantage to ſcience will ariſe from it?

To this I ſhould anſwer, that it is and muſt ever be of importance that we ſhould entertain correct notions concerning the operation of the ſenſitive faculties; and though no immediate advantage to the ſcience of optics may at preſent reſult from it, yet it is a fact in the general philoſophy of the human mind highly worthy of notice, and from which various important deductions may probably be made reſpecting percipiency in general. The preſent, however, is not the time for purſuing the ſubject in that line.

But there is one queſtion which has been much agitated among optical writers, in which the poſition juſt proved will certainly apply to ſome advantage; the queſtion is this, Why do we ſee objects erect by means of inverted images? Every one moderately read in optics muſt know how much this queſtion has occupied the attention of optical writers; but if we admit the theory now ſtated, the queſtion itſelf vaniſhes; for it implies what is not a fact, namely, that the external objects are ſeen, and not the images; but the truth is, that the images are not inverted, for the objects we ſee are erect, and theſe, it has been ſhewn, are the images.

THERE is a ſolution of the above queſtion by Dr. Reid, on which I ſhall make a few remarks, becauſe the author draws from it a concluſion which I conceive to be altogether inconſiſtent with the nature of viſion; which is this: "that if the projections "on the retina had been the reverſe of what "they now are, the mind would have ſeen "all objects in an inverted poſition." This author has laid it down as a law of nature in viſion, that we ſee objects in the direction of a line paſſing from the picture on the retina through the centre of the eye; and by this law of nature he ſolves the queſtion; ſince the lines thus paſſing from the extremities of an object projected on the retina muſt of courſe croſs each other.

BUT this is rather to cut than to looſen the knot; it is only ſaying that we ſee objects erect in conſequence of a law of nature; and when this law comes to be explained, it only expreſſes the fact itſelf in other words.

BY a law of nature in viſion I can only underſtand ſome original mode of action ariſing from the ſtructure of the organ, and its natural effect on the mind; and not thoſe habits of aſſociation which are founded on cuſtom and experience. Thus, the habit of aſſociating the notion of diſtance to certain viſible perceptions, though general throughout mankind, cannot with ſtrict propriety be termed a law of nature in viſion, becauſe it does not ariſe from any circumſtance in the ſtructure or conformation of the eye, nor is it deducible from any known principle in optics, but is founded on experience, or on the habit acquired of combining tangible with viſible notions; and it is very poſſible, that a human being with perfect eyes might be placed in ſuch circumſtances as never to acquire this experience, and conſequently never to unite to his viſible perceptions the notion or conception of diſtance in a line from the eye; and ſince the direction of an object from the eye implies this kind of diſtance, and is indeed a modification of it, it cannot be ſaid that we ſee objects in any direction from the eye in conſequence of any law of nature in viſion.

We know by experience, that an object is only ſeen clearly and diſtinctly when the projection falls on a certain point of the retina, generally ſuppoſed to be its centre. This point is the centre of the field of view, and the viſible place of every other object is determined by its ſituation on the retina relative to this centre; and from the habit of directing the eye upwards or downwards, or to one ſide or the other, in order to bring an object on the centre of the retina, that it may be diſtinctly ſeen, is derived the notion of direction from the eye. To *look at an object* is only to bring the projection on the centre of the retina. Dr. Reid's ſolution therefore only amounts to this, that objects appear erect from the habit of judging them to be in a certain direction from the eye; which I conceive to be only expreſſing the fact in other words; the queſtion is, What is the foundation of this judgment?

Every one knows that inverſion is only a relative term. One individual figured object exiſting in abſolute ſpace, whatever might be its ſituation, could never be in an inverted poſition ſo long as it remained ſingle; two objects at leaſt are neceſſary to give riſe to the relation of inverſion; and the ſame holds true of a whole ſet of objects, which, while retaining their proper relative poſition among themſelves, could never be inverted, whatever might be their poſition in abſolute ſpace. Here ſome other object, diſtinct from the ſet, would be neceſſary to ſerve as a ſtandard of compariſon, or in reſpect to which the other might be inverted.

BUT the whole of viſible nature conſiſts of a ſet of figures projected on the retinæ, made perceptible by the ſenſation of colour, which, ſo long as they preſerve their relative poſitions among themſelves, cannot be inverted. We call that the upper part which is toward our head or toward the ſky, and that the lower part which is toward our feet or the ground; and the ſame with reſpect to the right or left hand. But this head or this ſky, or the ground or our feet, and the right or left hand, are equally viſible objects projected on the retina. That object is erect whoſe upper part, or that part which points toward the ſky, is poſited on the retina toward that part where the ſky itſelf is alſo poſited on the ſame membrane; and that object is on the right hand, whoſe poſition on the retina is on that ſide of it where the right hand itſelf is alſo poſited.

Nor does the abſolute poſition of an object in reſpect to the retina itſelf determine its erectneſs or inverſion; for in every inclination of the head the general ſituation of the objects on the retina muſt alter, while, their relative poſition remaining the ſame, the objects preſerve their erect appearance. In a recumbent poſture the projections will be tranſverſe on the retina, but the erect appearance will remain; and that equally, whether the upper part of the object is projected on the right or on the left ſide of the retina, according as we lie on one ſide or on the other.

Let us now ſuppoſe, for the thing is poſſible, a perſon to be confined from his birth in one poſition; his limbs and head to be made immoveable, and all intercourſe with beings ſimilar to himſelf to be abſolutely precluded. Such an one, his eyes being perfect and his ſight free, would have the ſame *viſible perceptions* as another; and whatever may be truly called laws of *nature in viſion* would take place in this being; but as he could not, in this ſituation, acquire the habit of combining tangible notions with his viſible perceptions, theſe laſt muſt conſequently remain ſeparate and in their original form. Such a being would perceive a conſtant ſucceſſion of viſible objects appearing and vaniſhing from ſight after various modes. The diminution of apparent magnitude, the various gradations of light and ſhade, and other circumſtances which to us ſuggeſt diſtance, would to him be only a variation of appearance. He would have no notion of the figure of his own body, or of his own eyes conſidered as the inſtruments of ſight; and every thing would ſeem to him as within himſelf. The poſition of objects would be in his apprehenſion only a relation among themſelves, but no relation in reſpect to himſelf as the percipient; the diſtance of one object from another would appear only as a diſtance on the ſame ſurface; but of diſtance or direction from *himſelf* he would have no idea.

But this being would ſee all objects erect; that is, he would ſee them in their true relative poſitions in reſpect to each other. If he ſaw a tree, he would ſee the trunk toward the ground and the branches toward the ſky. If he ſaw a man, he would ſee his feet on the ground and his head in the air, in the ſame manner as we do. The objects on his retinæ would occupy the whole of viſible ſpace. And in order to form the notion of inverſion, ſome object diſtinct from the things he ſaw would be neceſſary, in reſpect to which they might be inverted; but ſuch a notion he would not be able to form; and all this would equally take place, whatever might be the real original poſition of theſe objects on his retinæ, whether vertical, in either direction, or horizontal or oblique; for, the poſition of the objects being merely a relation ſubſiſting among themſelves, and no relation in reſpect to the mind which perceives them, it follows, that ſo long as they preſerved their true relative poſition in reſpect to each other, they muſt appear to the percipient in their proper or erect ſituation; for there can be no inverſion of an entire ſet of objects in abſolute ſpace.

When Dr. Reid then concludes, that if the objects had been originally all projected on the retina in a ſituation the reverſe of what they are now, they would have appeared to be in an inverted ſituation, I think he totally miſapprehends the matter;

for, the erection or inverſion has no dependence whatever upon the abſolute poſition of the *whole ſet* of objects. And had this been the order in which nature had placed the objects on the retinæ, the notions of touch would, by experience and habit, become regularly aſſociated to this order of appearance; for the body and limbs would in this caſe have the ſame relative poſition in reſpect to the ſurrounding objects as they have now.

If it were required, for inſtance, to reach an object from the ground, or from above the head, we ſhould of courſe extend the hand toward the place where the object appeared to be ſituated. If an object were ſituated on either ſide of us, we ſhould, in order to reach it, naturally extend towards it that hand which appeared to be on the ſame ſide as the object.

Upon the whole then it appears, that optical writers have perplexed themſelves in ſolving a difficulty of their own making. The notion of inverted images is founded on comparing the ſet of objects which we do ſee with an imaginary ſet of things which we do not ſee. If we could ſee the objects as they would appear projected in the eyes of a living body, we ſhould ſee them inverted with reſpect to thoſe we ſaw direct; but, as has been already noticed, the things we ſhould ſee in this caſe would not be the real projections in the eye of another, but a minute ſet re-projected on our own eyes; and ſince it follows from the common laws of projection, that theſe minute objects would appear in an order inverted in reſpect to the real projections in the other eye, we muſt allow, if we call the former inverted, that the real projections would be erect.

ANOTHER queſtion in viſion which has been at leaſt equally agitated with the former is, How we are to account for ſeeing objects ſingle with two eyes?

It is a well-known fact, that in order that the ſingle appearance ſhould take place, it is neceſſary that the eyes ſhould be in a certain poſition in reſpect to the object, or that the projections of the ſame object on each retina ſhould fall on certain points, which optical writers have called correſponding points; and this correſpondence has by ſome been attributed to cuſtom and experience, and by others conſidered as the conſequence of ſome original law in the human conſtitution.

Dr. Wells conſiders the ſingle appearance as the neceſſary reſult of a law whereby objects appear to lie in a certain line of direction; which law is ſuppoſed to affect each eye when uſed ſingly, in the ſame manner as when the two are uſed conjointly; in conſequence of which law an object in a certain ſituation, appearing to each eye to lie in the ſame line of direction, muſt of courſe appear ſingle.

This theory of viſible direction and its conſequences will form the ſubject of the following Sections *.

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* Having throughout the foregoing account of viſion ſpoken of the tangible objects as being real and external; I might perhaps be aſked by certain perſons, on what ground externality or reality can be attributed to the tangible, rather than to the viſible object? But the diſcuſſion of this queſtion would lead us into the depths of abſtruſe, metaphyſical reaſoning, and is foreign to our preſent purpoſe. I am ſenſible that the principles of Dr. Berkeley and Mr. Hume reſpecting material exiſtence are adopted by ſeveral perſons of eminent talents in the preſent day, and I believe are daily gaining ground. However, I conceive that what has been here advanced reſpecting viſion is not affected by this queſtion which ever way we take it. They who embrace the ideal ſyſtem muſt allow that there is a certain proceſs of nature in viſion whether the objects concerned in it have any permanent exiſtence independent of the mind or not. The tangible object; the rays of light; the projections on the retinæ are not abſolute non-entities: they are certain things cognizable by our faculties, whatever may be the nature of their abſolute exiſtence; and to theſe philoſophers I ſhould ſay, that optical writers in general explain the viſible object as having a relation to, and connection with, one part of the proceſs, namely, that which we in general conſider as the external object, whereas I conſider the viſible object as being connected with, and dependent upon, a different part of the proceſs, namely, that part which we call the projections on the retinæ.

SECTION IV.

Dr. Wells's Theory of Viſible Direction examined, and the Queſtion, Why Objects appear Single to Two Eyes? conſidered[*].

I NOW propoſe to examine the theory of viſible direction laid down by Dr. Wells, and particularly to conſider whether it really affords an adequate ſolution of the queſtion, Why objects appear ſingle when ſeen by both eyes?

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[*] NOTWITHSTANDING the doctrine I have myſelf laid down, reſpecting the true nature of the immediate objects of ſight, I find myſelf in ſome degree under the neceſſity of conforming at times to the general mode of expreſſion, and I give this notice, in order to prevent ſuch inſtances from being brought againſt me as a contradiction of my own doctrine.

PHILOSOPHY in general would require, equally with the ſcience of chemiſtry, a new nomenclature and a new conſtruction of phraſes, if we would expreſs ourſelves with ſtrict accuracy.

I HAVE hitherto conſidered it as a fact in viſion, that objects appear united when their projections fall on the centers of the retinæ, or on points ſimilarly ſituated with reſpect to the center; but it may be neceſſary to obſerve, that in ſpeaking of the center of the eye, or of the retina, and of ſimilar points, I do not conceive that abſolute geometrical accuracy is required; for true geometrical figures are mere creatures of the mind, and have no exiſtence among external objects: An abſolutely perfect ſphere or cube is nowhere to be found in nature. It will, I apprehend, be generally allowed, that in a ſound ſtate of the eye the point where the optic axis terminates on the retina may in reſpect to ſenſe be conſidered as the center*; and I ſhall adopt the definition of the optic axis which Dr. Wells has laid down. If the termination of this axis on the retina is not preciſely the center, ſtill I conceive that the law of viſible direction mentioned by Dr. Smith and by Dr. Reid, will not be affected by ſuch trifling deviation from ſtrict geometrical preciſion. It is a fact, that points whoſe projections on the retina are the terminations of theſe axes, appear united; and the queſtion I mean to conſider is, Whether this apparent union is the cauſe of ſome law of viſible *direction from the eye?* or, Whether it reſults from ſome original property independent of any ſuch law of viſible direction?

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* WHEN we conſider the uſe of the eye, there appears reaſon to ſuppoſe it adapted with no ſmall degree of accuracy to its peculiar functions; and I conceive it to be probable, from the nature of the eye conſidered as an optical inſtrument, that the ray of light which paſſes perpendicularly through the center of the cryſtalline comes to it unbent, and is in fact the true optic axis. If the obſervations of anatomiſts are founded

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founded on experiments made on the eyes of dead animals, the preciſe form thus determined cannot, I think, be depended upon. However, it ſeems an acknowledged fact, that there are certain points of one retina which correſpond with certain points of the other; inſomuch, that the objects projected on theſe points reſpectively appear united: the correſpondence of the points I conceive is founded on this property of producing a ſingle appearance, and not a ſtrict geometrical ſimilarity.

I PERFECTLY agree with Dr. Wells in rejecting the opinion of Dr. Smith, who derives the union of theſe points, or the ſingle appearance, from cuſtom or the habit of correcting viſible notions by the knowledge acquired from the ſenſe of feeling; and I ſhould think it a ſufficient objection to this ſolution to ſay, that if the ſingle appearance is founded on a knowledge of the unity of the external object, derived from the ſenſe of feeling, a ſingle appearance ought not to take place when we previouſly know there are two external objects; but it is a well-known fact, that two diſtinct ſimilar objects may, in a certain ſituation of the eye, be made to appear as one; however, independent of this, there are various other inſurmountable objections to this ſolution.

THERE is an experiment reſpecting the ſenſe of feeling, which has frequently been adduced as an inſtance of fallacy in that ſenſe of a ſimilar nature with the fallacies of ſight*; I mean the double ſenſation occaſioned by feeling any object, as a button or a marble, with the oppoſite ſides of two contiguous fingers laid acroſs; but this ſuppoſed fallacy is founded on the inaccuracy of our conceptions reſpecting the unity of an object; for, to ſpeak ſtrictly, the different parts of an extended object are really different things; and it is impoſſible to feel the ſame thing at the ſame time with two fingers, becauſe two fingers cannot at the ſame time be applied to one and the ſame part of any object.

THE circumſtance which in our judgment conſtitutes the unity of an object has, in this caſe, no relation whatever to the ſenſation. Let a marble be firſt felt with the fingers croſſed, and in this ſituation the oppoſite ſides of the marble are what we feel with the different fingers. Now, ſuppoſe the marble to be cut into two parts, and let each part be felt reſpectively by the ſame fingers as before, uncroſſed; in this ſituation we ſhould not ſcruple to ſay, that we had a feeling of two diſtinct things; but what we feel now are preciſely what we felt before; and I find, that when feeling an object with my fingers ſtretched apart, but not croſſed, I can, with a ſmall degree of attention, catch the ſame notion of duplicity as when the fingers are croſſed; the truth is, the fallacy lies in the judgment we form of the relation which the parts felt by the different fingers have to each other. But in the caſe of ſingle viſion the circumſtances are entirely different; for here the very ſame points of what we call the external or tangible object are ſeen by each eye. I have adverted to this fact reſpecting the ſenſe of touch, as ſerving to ſhew how apt even perſons accuſtomed to deep inveſtigation are at times to think with inaccuracy.—But to proceed.

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* THIS circumſtance is mentioned by Dr. Smith in his Syſtem of Optics.

Dr. Reid is of opinion, that the apparent union of the centers and ſimilar points of the retinæ is the conſequence of ſome original law of our conſtitution ; in which doctrine I am inclined to concur, for reaſons which will be hereafter mentioned. To this opinion Dr. Wells objects, that it ſtands in oppoſition to a very extenſive analogy, which teaches us, that when two organs of a ſimilar kind are found in the ſame individual, the correſponding parts of ſuch organs are found to be at equal diſtances from the plane of partition ; agreeable to which rule, inſtead of a correſpondence between points ſimilarly ſituated on the retinæ with reſpect to the center, we ſhould have a point on the right ſide of one retina correſponding with a point at an equal diſtance from the center on the left ſide of the other retina.

This objection, however, appears to me to have little weight ; but while I ſay this, I muſt confeſs that my knowledge in anatomy is too limited to render me competent to a full diſcuſſion of the queſtion. There is, however, one circumſtance reſpecting the human eyes which, I think, may account for what Dr. Wells terms a violation of a very extenſive analogy; this is, the parallel motion of the eyes. If we extend the analogy mentioned by Dr. Wells to the motion of ſuch ſimilar organs, we ſhould naturally expect that it would be in oppoſite directions; that when one moved to the right the other ſhould move to the left, in order to preſerve an equal diſtance from the plane of partition; but we know that there is a law of motion in the eyes directly contrary to this; and that when one moves ſo as to increaſe the diſtance of the centre of the retina from the plane of partition, the other at the ſame time moves in ſuch a manner as to cauſe the centre of the retina to approach this plane.

I UNDERSTAND there are ſix muſcles belonging to each eye which regulate their motions, of which four are called ſtraight, and two oblique muſcles. Now it appears to me, that, agreeable to the rule here mentioned, we ought to expect the correſponding muſcles to act at the ſame time, the external ſtraight muſcle of one to act with the external ſtraight muſcle of the other eye, and ſo of the reſt; and in that ſet of motions which regulates the inclination of the optic axes to each other, this really does take place; but in the more general ſet of motions by which the eyes are carried together to the right or to the left, the external muſcle of one acts with the internal muſcle of the other: and if it could be ſhewn, which I apprehend is probable, that in general where there are double organs, the correſponding parts of ſuch organs act together, there would then appear a reaſon, drawn from the nature of the functions of the eyes, for departing in this inſtance from the general analogy. To this we may add, that if ſingle viſion be the conſequence of an united impreſſion or ſenſation, which is at leaſt a probable ſuppoſition, the general laws of optical projection require, that this property ſhould reſide in points, which do not agree with that rule of correſpondence which takes place in other double organs whoſe functions are different: and theſe conſiderations appear to me ſufficient to invalidate the arguments *à priori* which Dr. Wells has founded on analogy.

WITH reſpect to thoſe derived from the conſequences of Dr. Reid's theory, I have but little to obſerve. The firſt is founded on that writer's notion concerning viſible place, in which I totally differ from him; original viſible place does not include either diſtance or direction from the eye. In regard to the ſecond, it will, I think, appear that the facts are in favor of Dr. Reid, and that an object at reſt does appear to move as ſeen by one or the other eye alternately, of which more will be ſaid hereafter. The third objection relates to a caſe of ſquinting, on which I am not competent to ſay much, never having had opportunities of making obſervations on ſuch caſes; but conceiving them to be anomalous ſubjects, I ſhould not conſider it as making againſt the general doctrine, even if it ſhould be found, that the points where the optic axes terminate in ſuch eyes do not appear united; and indeed this caſe is no more to be reconciled to the theory of Dr. Wells than to that of Dr. Reid. Having made theſe remarks on the objections brought by Dr. Wells againſt the theory of an original correſpondence between the centres and ſimilar points of the retinæ, we may proceed.

One important obſervation which occurs on the outſet of an inquiry concerning the cauſe of ſingle viſion is, that it can be no queſtion with any who maintain that we ſee external objects, or ideas correſponding with ſuch objects; for if we ſee external objects, and thoſe objects are ſingle, we muſt neceſſarily ſee them ſingle; that is, we muſt ſee them as they are, independent of any number of eyes.

If the mind is endowed with a power of perceiving external things, the *mode of perceiving* can make no difference in the thing perceived; the number of the organs concerned cannot increaſe the number of the things to be perceived, and it muſt be impoſſible to ſee two things where there is only one thing to be ſeen. What has been obſerved in the preceding Sections renders it needleſs to dwell on this poſition here; and indeed it carries its own evidence on the face of it. But conſidering the projections on the retinæ as the direct objects of viſion, it becomes a rational and philoſophical queſtion, Why, in a certain poſition of the eyes, the two projections appear united as one, or ſeen under the ſame outline? and I profeſs myſelf to be one of that claſs mentioned by Dr. Wells, which conſiders ſingle viſion to be the conſequence of an united impreſſion or ſenſation;

tion; and though it may not be poſſible to produce ſuch evidence for this opinion as may amount to abſolute demonſtration, yet I think it may be ſhewn, that there is nothing in this new theory to ſet ſuch a notion aſide; and that the evidence for it is ſuch as to render it, if not certain, at leaſt highly probable.

The ſolution of our author makes the phenomenon of ſingle viſion the *conſequence* of a certain law of viſible direction; but I aſk, may not the apparent union of the object be the original fact, and this law of viſible direction a certain conſequence of ſuch united appearance?

To account for a phenomenon in nature is to trace it up to ſome law more general than itſelf, and of which the fact is one neceſſary conſequence; thus, water riſes in a pump from the ſame principle by which a ſtone falls to the ground, or by which water deſcends in rivers to the ſea; that is, from the general principle of gravitation. But this law of viſible direction, admitting it to be juſt, is not more general than the fact it is brought to explain: it is indeed leſs general; for the apparent union of the optic axes may be conſidered as being only one inſtance of the general ſingle appearance of objects.

If it could be made to appear, that the ſame ſeeming direction of objects, placed in either optic axis was the original law, we might then conſider the united appearance of objects as the *conſequence* of ſuch law. But, on the other hand, if the apparent union of objects projected on certain points of each retina is the original fact, the various circumſtances of ſeeming direction, may be deduced from ſuch united appearance.

Which circumſtance then is prior in the order of things? Was there ever a time previous to the acquiſition of certain habits of judging, when objects did not appear ſingle even in that poſition of the eyes in which we now know that they do? If this queſtion could be anſwered in the affirmative, it might go a conſiderable way towards eſtabliſhing the theory of Dr. Wells as an adequate ſolution of the queſtion reſpecting ſingle viſion; but we have every reaſon to ſuppoſe the fact is otherwiſe; circumſtances will be mentioned in the ſequel which tend to prove that the ſenſation is united; and we know that the young gentleman couched by Mr. Cheſelden, on firſt receiving his ſight, ſaw objects ſingle, though he thought all things touched his eyes, and therefore could not ſee them in any direction *from the eye.*

BUT of viſible direction we may ſpeak with more certainty; this being a modification of diſtance from the eye, and neceſſarily implying it: but it is generally allowed that ſuch diſtance or the third dimenſion is no direct original perception by ſight, and conſequently the notion of direction from the eye muſt alſo be acquired. There is, however, a paſſage in the Eſſay on Single Viſion which ſeems to imply, that the writer admits diſtance in the abſtract to be an original perception by ſight, conceiving the meaſure or quantity of ſuch diſtance only, as not perceivable. The paſſage is this: "If diſtance be not immediately per-"ceivable by ſight, the only manner in "which an original property of the eye "can affect the viſible places of bodies is "by occaſioning them to appear in certain "directions*, &c." This evidently implies that viſible direction, which is a modification of diſtance, is the conſequence of ſome *original property*. But this is contrary to the general opinion of writers on this ſubject, who hold that the third dimenſion cannot be an original object of ſight; ſince the projection of the whole optic axis is merely

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[*] Essay on Single Viſion, p. 27.

a ſingle point, and the notion of externality and remoteneſs is the reſult of experience, and acquired by degrees.

In the laſt Section we imagined a being to have been kept from his birth in ſuch a ſituation as to have no opportunity of combining tangible notions with his viſible perceptions. Such a being as is there ſuppoſed would have no conception of eyes as the organs of viſion, or as having any relation of direction in reſpect to viſible objects. He would have no notion of the remoteneſs or externality of the objects he ſaw, but every thing would appear as within himſelf, and the whole ſet of objects would appear as figures variouſly coloured on a plane ſurface.

Original viſible place neither includes diſtance in a line from the eye, nor direction from the eye; but is the relative poſition of the object on a plane, in reſpect to other viſible objects, and is to be eſtimated by its diſtance and direction, not from the eye, but from ſome other object in the ſame plane.

Every perſon acquainted with optics and the nature of viſion knows, that what is generally comprehended under the term *ſeeing*, is a complex operation; an art acquired by degrees, in which judgment and imagination are concerned together with ſimple perception. It has already been ſhewn, that the objects which we actually ſee are only the projections on the retinæ. The laws of projection of ſolid figures on a plane ſurface have been accurately inveſtigated, and conſtitute the ſcience of perſpective; and the art of ſeeing may be conſidered as a ſort of anti-perſpective, or the re-projection or throwing out of points and lines from a plane into diſtance and ſolidity; an art which we begin to practiſe from the earlieſt infancy, and whoſe firſt imperfect beginnings are beyond the utmoſt reach of memory.

The projection of each optic axis is a point on each retina, on or nearly on its centre, and if theſe points are, as I ſuppoſe, united in the mind by ſome original law of our conſtitution, forming only one perceptible point, the re-projection, as mentioned above, muſt in that caſe be one line. And ſince this re-projection is not a direct operation of ſight, but of ſome other faculty, that is, as direction from the eye is only adjudged, and not ſeen, it appears to me, that to ſay the optic axes appear united in the common axis, is only another mode of expreſſing the apparent union of the objects, or of the central points of the retinæ: in one caſe, we conſider the ſingle appearance as the conſequence of the two objects occupying preciſely the ſame place on the *viſible plane*; in the other caſe, we conſider the objects as thrown out into diſtance from the eye; and then we conceive the two as appearing in the ſame direction; and even if we ſhould take up the matter in the latter form, there would ſtill ariſe this queſtion, Why do the two optic axes appear united throughout their whole length? which is only another mode of ſtating the queſtion, Why do objects appear ſingle as ſeen by both eyes? But if we ſhould conſider the two circumſtances, *united appearance* and *ſeeming direction*, as being one derived from the other, I conceive it to be moſt conſiſtent with the rules of ſound philoſophy, to conſider the latter as the conſequence of the former, the firſt being an actual matter of ſight and the other an acquired motion, which is properly to be referred to ſome faculty diſtinct from ſimple viſion; and I apprehend that every propoſed ſolution of this celebrated queſtion, which derives the ſingle appearance from circumſtances which imply externality and remoteneſs in the objects of ſight, muſt be erroneous and unfounded.

I PROCEED to make ſome obſervations on Dr. Wells's propoſitions reſpecting viſible direction; and I think it will be found, on examination, that it is only from the mode of expreſſion that this theory is conceived to differ from that of former optical writers. I ſhall adopt the terms and definitions laid down by Dr. Wells, adding to the former the term *optic plane* for that which paſſes through each optic axis perpendicular to the plane in which the optic axes and common axis lie.

EVERY one knows that direction is a relative term, and that the ſame object may have various directions as eſtimated from different points; the direction of one point may alſo be relative or abſolute with reſpect to ſome other point, and either of theſe may vary while the other remains fixed. When we ſpeak of the direction of an object from ourſelves, or from the eye, we muſt conſider the eye as a point, and, conceiving ſome other point at a diſtance, to which a right line may be drawn from the former, all objects in this line, or every point in it, will have the ſame direction from the eye.

In eſtimating viſible direction we generally have reſpect to the optic axis; we conſider that point which we ſee moſt diſtinctly, or to which we immediately direct our ſight, as being directly before us, and it is with reſpect to this point that we eſtimate the direction of others, as lying to the right, or to the left, above, or below, &c. Suppoſe three ſpots upon a wall at the diſtance of a foot from each other; when we look direct at the middle ſpot, we conceive the others to be, one on the right, and the other on the left of the eye; when we look direct on the left ſpot, we conſider the other two as on the right of the eye; and when we look at the right ſpot, the other two appear to be on the left of the eye: but the abſolute direction of each ſpot from either eye remains the ſame in every circumſtance. In ſhort, the centre of the field of viſion is the point with reſpect to which we eſtimate viſible direction; a point which, in all the variety of abſolute direction, preſerves always the ſame relative direction from the eye or eyes. But we may here remark, that we have no perception of our own eyes as the organs of viſion; nor have we originally from nature even a conſciouſneſs that we ſee with double organs; it is impoſſible that our eyes can become objects of ſight to ourſelves; and in eſtimating viſible direction, their ſituation is only a matter conceived in the mind.

Let A B C D *fig.* 1, repreſent an eye, and let C be that point on the retina where the projections are moſt diſtinctly formed; and let P be any diſtant point whoſe projection on the retina would be on the point C and join C P; then will C P be the optic axis, agreeable to the definition of Dr.

Wells; in which, I apprehend, Dr. Reid or Dr. Smith would concur. Whether this point C be or not the preciſe geometrical centre of the retina, or whether the line C P does or does not paſs with ſtrict accuracy through the centre of the eye, are circumſtances which will not affect the queſtion we are conſidering.

Let O be ſome luminous point in the optic axis or line C P, from which a pencil of rays is ſuppoſed to iſſue covering the pupil E D, and which we know will be collected on the ſame point C *. Now, what Dr. Smith and Dr. Reid have ſaid reſpecting viſible direction is this: that the point O will not appear either in the direction of the ray C E or of the ray C D, or of any intermediate ray between theſe and the ray C O; but that it will appear in the

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* The point O is ſuppoſed to be at ſome diſtance from the eye; if it were near, the point C would lie beyond the retina, but ſtill in the optic axis produced.

direction of this central ray C P or C O, which Dr. Smith calls the viſual ray, and which in this caſe is the optic axis; and this, I ſuppoſe, no one will deny; for, what is the circumſtance which conſtitutes the being ſeen in this direction? It is the viſible coincidence of the points O and P: the line C P is the optic axis; and if the point O did not appear in the direction of this line, it could not be ſeen to coincide with the point P, but muſt ſubtend ſome angle with it at the eye; and it is of no conſequence in what part of the line C P we take the point P, whether at the ſuppoſed concurrence of the two axes, or on either ſide of that point; it will ever be in the optic axis, and the projection of every point in this line will be on the ſame point C of the retina, and every other point which is ſeen to coincide with the point P muſt appear to be in the optic axis. To this ſtatement of Dr. Smith's theory of viſible direction I conceive no objection can be made*.

LET us next examine the leading propoſition of Dr. Wells, "that objects ſituated "in the optic axis do not appear to be in "that line, but in the common axis." And it appears from what is ſaid on this ſubject, that the author conſiders this law of viſible direction as affecting each eye ſeparately and independent of the other; and to hold equally, whether the object is ſeen by one eye at a time or by both.

THIS propoſition certainly appears to be directly contradictory to what we have been conſidering above; let us then try if we can find any means to reconcile them †.

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* I HAVE only conſidered here the optic axis; but it is obvious that the ſame reaſoning muſt apply to the central ray of any other pencil of rays, the projection of every point of which will be on the ſame point of the retina.

† THE lines which Dr. Wells calls the optic axes are not ſtrictly ſo; for the real optic axes are only apparent points; but

In *fig.* 2, let the two eyes be repreſented at A and at B, and let the axes interſecting each other at the point P be determined as before; join D D the centre of the corneas, and from P draw the line P M to the middle of the line D D; then will P M be what Dr. Wells calls the common axis. Now, we know that the whole of the lines AP and BP, or that every point in them, will be projected on the reſpective retinæ at the ſame point C*, and conſequently cannot appear as lines, but will form only viſible points; whereas the common axis P M will be projected as a line on each retina, and will therefore be to each eye a viſible line. To ſpeak

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but a line drawn from the point of interſection of the axes, in what I have called the optic plane, though ſomewhat above or below, may be taken for ſuch, without affecting the concluſions; and I ſhall take the ſame liberty of calling ſuch lines the optic axes.

[*] Here again I obſerve, that the points of the axis near to the eye are not accurately projected on the point C, but on a point lying beyond the retina in the axis produced; but this circumſtance does not any way affect the reaſoning here uſed.

ſtrictly,

ſtrictly, then, if an object ſituated in the real optic axis does not appear to be in it, but to be in the common axis, ſuch object muſt appear to be where the common axis appears to be; but if we ſhould take the propoſition in this ſenſe it will not hold to be true. Or, again, we may ſay, that if an object or a point does not appear to be in the optic axis, ſuch object or point cannot appear to coincide with the point P, which is avowedly in ſuch axis, and then again the propoſition will not hold.

The truth then I conceive to be this: it is not that a point ſituated in the optic axis appears to be out of ſuch axis; but it is the optic axis itſelf which we conceive as lying in the direction P M; and the propoſition might, I think, have been better expreſſed by ſaying, that the two optic axes appear united in the line P M; for in the experiments mentioned by Dr. Wells with different-coloured ſtrings, it is certainly the line C P, or the optic axis, which we ſee, notwithſtanding it ſeems to us to be ſituated in the line M P; and, again, that is really the middle line M P which we conceive to be in the ſituation C P; and that line which we are apt to conceive of, as being one of the optic axes, ſay the right, is in truth a line which has no reſpect whatever to the right eye, but is the common axis or line M P as ſeen by the left eye *.

It would, perhaps, tend to render my meaning clearer if we conſider one eye only; and if it ſhould be ſaid, that objects ſituated in the axis of this eye do not appear to be in it, I would aſk, In what line do they appear to be? or, If that is not the optic axis which we ſee, notwithſtanding we conceive it to be in the ſituation M P, which is the optic axis as ſeen by this one eye? and we certainly ſhall find, that there is no other line, that we can conceive as ſeen

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* See the 2d propoſition in the Eſſay on Single Viſion, &c. page 46.

by this eye, which can have the characteriſtic property of the optic axis, which is, that every point of it ſhall be projected on the ſame point C of the retina.

THE difference then between the two theories appears to me to lie in an ambiguity, the one ſpeaking of an external line, the other, of a conceived or apparent line. But I repeat what I have ſaid before, that no point can properly be ſaid to appear out of the axis which is ſeen to coincide with the point P, which is confeſſedly in the axis; and the two theories may, I think, be reconciled, if, inſtead of conſidering points ſituated in the axis as appearing out of it, we conceive the whole axis itſelf as having a certain apparent ſituation. However, I lay no great ſtreſs on this; for the circumſtance of ſingle viſion is, as I conceive, perfectly independent of one or other of theſe theories, or, indeed, of any law of viſible direction whatever.

And what, after all, is this apparent coincidence of the optic axes, but one inſtance of the united appearance of objects? And as ſuch, how can it afford an adequate ſolution of the general queſtion? We may ſtill aſk, Why do the optic axes appear united throughout their whole length? A queſtion which remains unſolved by any thing contained in the Eſſay on Single Viſion; for, to ſay, that objects ſituated in the optic axes appear in the ſame direction to each eye, is only expreſſing the apparent union in other words. This circumſtance has been long known to optical writers, as is evident from the conſtruction of the binocular teleſcope; and when we conſider that the optic axes are only apparent points, and conſider further that the notion of direction from the eye, or the habit of throwing points and lines out into diſtance and ſolidity, is acquired by degrees, it would ſurely be more reaſonable to derive the apparent direction from the union of the points, than to conſider the latter as the conſequence of the former.

SECTION V.

Experiments inconſiſtent with the Theory of Dr. Wells.—An Attempt to explain ſome Principles which influence the Notion of viſible Direction.—Recapitulation.

THE apparent union of the optic axes, when the eyes are uſed conjointly, does, I believe, in a ſound ſtate of the organs, extend to all caſes whatever. But I ſhall produce ſome experiments which prove that theſe axes, as ſeen ſeparately by each eye, reſpectively, have a different apparent direction one from the other, and each from that of the united axes when ſeen by both eyes together; which is directly contrary to the opinion of our author, who maintains, that the law of viſible direction which he has ſtated, affects each eye when employed by itſelf, in the ſame manner as when it is uſed conjointly with the other*; and the ſolution which this theory affords of the queſtion reſpecting ſingle viſion reſts entirely upon this circumſtance.

In the third part of his Eſſay Dr. Wells mentions ſome facts which are inconſiſtent with his own theory, but which might readily have been accounted for, or even predicted, from the theory of an original correſpondence between the points on the retinæ where the optic axes terminate. But this writer, in order to account for theſe appearances, has framed an hypotheſis, which, though ingeniouſly adapted to the intended purpoſe, has not, as I conceive, a foundation in the nature of things; and in ſubjects of philoſophical ſpeculation we muſt not reſt ſatisfied with ingenious hypotheſes.

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[*] Essay on Single Viſion, p. 42. 45.

When the Author, by looking ſteadily for ſome time at a luminous body, had acquired the ſenſation of a ſpot appearing upon the face of any object to which he directed his eyes, he acknowledges to have expected, that by forcibly altering the poſition of one eye, the ſpot would have appeared double, in conſequence of a variation in the direction of the optic axis of the diſtorted eye; contrary, however, to this expectation, the ſpot neither appeared to be double, nor to have altered its ſituation: but as the apparent ſituation of the ſpot may be changed by certain voluntary motions of the eyes, this Writer concluded, that apparent direction is dependent on the ſtate of action exiſting in the muſcles which move them.

On this I obſerve, that the ſingle appearance of the ſpot would follow, as a neceſſary conſequence of an original correſpondence between the points on the retina where the optic axes terminate; for the forcible diſtortion of the eye could not be ſuppoſed to affect ſuch an original property. The ſpot is a ſenſation or durable impreſſion on a certain part of the retina cauſed by a ſtrong light; and while the various objects projected on the retina change their poſitions, in reſpect to its centre, in conſequence of the forced diſtortion, it is evident, that the affection of the central part, cauſed by the ſtrong ſenſation of light, muſt remain as before the preſſure of the eye, and the ſpot muſt therefore appear united with that ſeen by the other eye, wherever it may appear to be; and the double appearance of other objects readily follows from the ſame ſource; for thoſe objects are, by the preſſure of the eye, protruded from thoſe ſimilar points, which they before occupied on the retina, and on which their ſingle appearance depends; while the objects whoſe projections now occupy theſe points will appear to be united with the former objects as ſeen by the other eye.

I PROCEED to ſtate ſome ſimple and plain experiments that are not to be reconciled with the theory of viſible direction which we have been conſidering.

EXPERIMENT I.

AFTER looking ſteadily for a little time at any object, for inſtance, a lighted candle, at the diſtance of three or four feet, let the eyes be cloſed alternately, the object being ſeen by only one at a time, and it will appear to have a motion from ſide to ſide, ſeeming to move to the right when ſeen by the left eye, and to the left when the right is uſed; and when ſeen by both eyes at the ſame time, it will appear mid-way between the two places where it appeared to the different eyes ſingly.

WHEN I firſt tried this experiment I cloſed my eyes alternately with my fingers; but apprehending it poſſible, that ſome deception might ariſe from a motion communicated to the eye by the act of cloſing it with the fingers, I procured two elliptic pieces of card of about two inches and a half in length, and two in breadth; theſe cards were blacked, and paſted on two ſmall ſticks of about eight inches in length to ſerve as handles. With theſe cards I repeated the experiment, keeping both eyes open, and continually directed to the object, but alternately placing a card before one and withdrawing it from the other, when the reſult was as before, and the object had an obvious apparent motion from ſide to ſide. This experiment I have very frequently repeated with the ſame appearance, and have cauſed various perſons who were occaſionally with me to try the ſame, and always with the ſame reſult.

EXPERIMENT II.

Let A and B *fig.* 3, be the places of the eyes, and P the mutual interſection of the optic axes when they are directed to the point P. Draw P M to the middle of the viſual baſe. Let O be any point or object in the right axis B P, and join O A and O M; then will P M be the common axis, or the line in which both axes appear to be united when the eyes are both directed to the point P, and O M will be the common axis when the eyes are directed to the point O; and, agreeable to the theory of Dr. Wells, the apparent direction of the points P or O, when the eyes are reſpectively directed to them, will be the ſame, whether they are ſeen by one eye ſingly, or by both at a time.

I provided myſelf with a thin board about eighteen inches ſquare, on which I paſted white paper; this board was fixed on a ſtand ſimilar to a fire-ſcreen. Through a ſmall hole made in it I paſſed ſeveral differently-coloured ſtrings held faſt by a peg, and on each ſtring I put a bead of a different colour. This formed a very ſimple and convenient apparatus for trying the experiments mentioned by Dr. Wells, as well as many others.

WITH this apparatus I held one of the ſtrings in the axis of the right eye, or, more ſtrictly ſpeaking, in the right optic plane ſomewhat below the axis, for I held it with my teeth on the right ſide of my mouth. The bead, which may be repreſented by the letter O in the *fig.* I placed about midway between the eye and the point P, and held in each hand one of the cards mentioned in the former experiment. Now I found, that when the card was held before the left eye ſo as to intercept its ſight, the bead or point O appeared to have preciſely the ſame direction, whether my eyes were directed to it or to the point P. This I tried frequently, alternately directing my eyes to one and to the other, without obſerving the ſmalleſt apparent motion, or any variation in the direction; but as ſoon as I withdrew the card from before the left eye, the two being directed to the point O, it immediately appeared to have a direction lying to the right of the former; and on covering the right eye, this direction became ſtill more inclined to the right; withdrawing the card from the right eye, and covering the left, the point O reſumed its former ſituation; and thus I tried it for a number of times with the ſame reſult. When I alternately placed a card before one eye, at the ſame time withdrawing that placed before the other eye, the apparent motion of the bead became extremely obvious.

There is, however, a circumſtance which might lead to deception in this experiment; which is, that when one eye only is uſed we may ſuppoſe the eyes to be directed to the point O, when in fact they are directed towards P, which would render the viſible circumſtances, on withdrawing the card from the other eye, ſomewhat different; in order therefore to obviate the poſſibility of being thus deceived, I varied the experiment in the following manner:

EXPERIMENT III.

On the ſcreen above-mentioned I drew a perpendicular line, in which I made a mark which we may call P*, and from an arm fixed to the ſtick of the ſcreen, I hung a plumb-line at the diſtance of about eighteen inches from the ſcreen; on this plumb-line I fixed a ſmall piece of card, on which a word was written in a ſmall character. This plumb-line, being interpoſed between the eye and the perpendicular line drawn on the ſcreen, at a nearly equal diſtance from each, might eaſily be brought to lie in either optic plane, by making it appear to coincide with the perpendicular line on the ſcreen, as ſeen by either eye.

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* In *fig.* 3.

I NOW ſituated myſelf ſo as to cauſe the plumb-line to lie in the right optic plane; and when the eyes were really directed to the point P in the perpendicular, the letters written on the card appeared too confuſed for the word to be legible; but when the eyes were really directed to the card, which in this experiment is the ſame as the point O in the 3d *fig.* mentioned above, the letters appeared diſtinct, and the word was plainly legible; and by theſe means I avoided being liable to the deception above ſtated.

Now, when the blacked card intercepted the ſight of the left eye, the two eyes being directed alternately to the point P and to the card, the reſult was preciſely as before, no motion or alteration of direction appearing, whether the eyes were directed to one or to the other of the objects lying in the right optic axis; but as ſoon as the card was removed, the eyes being directed to the bit of card on the plumb-line, or the point O, its apparent direction appeared to be moved to the right. When the cards were alternately uſed, the apparent motion became as before extremely obvious. And it is worthy of remark, that when both eyes were held directed to the perpendicular line on the ſcreen, both it and the plumb-line appeared to have a motion together from ſide to ſide, though not in equal degree, the plumb-line appearing to move through the greater intervals.

In this apparent motion of the optic plane there would have been nothing extraordinary had it appeared to move on the perpendicular line as a centre when the eyes were directed to this line; but in this caſe the centre of apparent motion lay more remote, and the perpendicular line, as well as the plumb-line, had an apparent motion from right to left, as one or the other eye was uſed.

This experiment may be varied, by making the object in the optic axis, here repreſented by O, a card with a hole in it about half an inch diameter, and fixed at the diſtance of about two feet and a half from the eye; by looking at ſome object at a little diſtance through the hole, the card may be kept in the optic axis; and when the eyes are directed to it and alternately covered, the apparent motion cannot be overlooked.

EXPERIMENT IV.

Let A and B *fig.* 4, repreſent the eyes, and the line A B the viſual baſe; upon the point M, equally diſtant from each eye, erect the perpendicular P M, in which take the points R, S, T, at any intervals, and join A R, A S, A T, and A P; and alſo B R, B S, B T, and B P; then will the line P M be the common axis while the eyes are ſucceſſively directed to the points R, S, T, and P. Now, agreeable to the theory of Dr. Wells, the points R, S, T, and P, as the eyes are ſucceſſively directed to them, ought to appear to be in the ſame direction, and the axes conſequently to be at reſt, notwithſtanding their real motion; and this ought to take place equally, whether one eye or both be uſed at a time, the law of direction, agreeable to this Writer, affecting each eye when uſed ſingly, the ſame as when both are uſed conjunctly.

On one of the ſtrings in the apparatus already deſcribed, I placed ſeveral beads at intervals, and held the ſtring in the common axis or line P M. Now, when both eyes were employed, and ſucceſſively directed to the

the points R, S, T, and P, each point appeared, agreeable to the theory, to lie in the ſame direction; namely, in that of the line PM; but when the black card was held before the left eye, and the two again ſucceſſively directed to the points R, S, T, they appeared each in a different direction, and the right optic axis had an apparent motion correſponding with its real motion from left to right.

FROM theſe experiments the following conſequences obviouſly reſult:

First, That an object, though ſituated at the concurrence of the optic axes, and conſequently appearing ſingle, has a different apparent direction as ſeen by either eye ſeparately, or by both eyes conjointly; and therefore the ſingle appearance of objects in a certain poſition of the eyes, cannot be the conſequence of a law of viſible direction affecting each eye ſingly in the ſame manner as when the two are uſed in conjunction. But, on the contrary, ſince the apparent union of objects projected on certain parts of the retinæ, when ſeen by both eyes, is a well-known and eſtabliſhed fact; and ſince an object thus ſeen ſingle has a certain apparent direction, lying midway between the two ſeeming directions, which the ſame object has, when ſeen ſeparately; it is ſurely reaſonable to conſider this intermediate direction as being compounded of the other two; and as the natural reſult of the united appearance.

Secondly, Different points in the ſame optic axis to which both eyes are alternately directed, do not, when one eye is covered, and they are ſeen only by that eye in whoſe axis the points lie, appear to have a different direction. And ſince there is, as avowed by Dr. Wells, a difference in the ſtate of action in the muſcles of the eye which alternately looks at the objects or points, it follows, that apparent direction is not dependent on ſuch ſtate of action in the muſcles; for, in this caſe, the direction remains the ſame, while the ſtate of action changes. But as the apparent direction alters when the object becomes viſible to the other eye, without any change taking place in the ſtate of action in its muſcles, we muſt ſearch for the cauſe of this ſeeming change of direction, in ſome *viſible circumſtance* affecting that eye by which the point or object is laſt ſeen.

WITHOUT pretending to bring forward a perfect theory, which may account for all the phenomena of the ſeeming direction of viſible objects, I ſhall point out ſome of the circumſtances by which I conceive it to be influenced.

THE firſt obſervation I have to make is, that, aſſuming as a fact, the exiſtence of ſome original property in the ſimilar points of the retinæ, in conſequence of which objects projected on theſe points appear to be united, we may from hence deduce the direction of the apparently-united optic axes as lying in the common axis; for, the projection on the right eye of that line which we have all along called the optic axis*, will be a vertical line paſſing through the centre of the retina †; and the projection of the left optic axis on the right eye will be a line extending to the right of the centre, and making a certain angle with the former. Again, in the left eye, the projection of its axis will alſo be a vertical line paſſing through its centre, and the right axis will be projected on this eye in a line extending to the left of the centre, making an angle with the projection of the axis preciſely ſimilar to that in the other eye.

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* IT has already been obſerved that theſe lines are not ſtrictly the optic axes.

† I muſt beg leave to remind the reader of what I have already ſaid reſpecting geometrical preciſion in ſpeaking of that point which we call the centre of the retina.

Now when, in conſequence of the above law, the two vertical lines or optic axes appear united, it is obvious that this united line muſt appear to make equal angles with the left axis on one ſide, ſeen by the right eye, and with the right axis on the other ſide ſeen by the left eye. So far we are clear; but any attempt to explain all the various phenomena of ſeeming direction from the laws of projection, muſt prove fruitleſs; let us, then, have recourſe to other conſiderations.

In what follows, I ſhall call the whole collection of viſible objects ſeen at one glance, or while the optic axes remain in one poſition, the field of viſion; and this, whether one eye only is uſed at a time, or the two conjointly. This field of viſion originally, and previous to all experience and exerciſe of the judgment, is a viſible ſurface differently coloured; and it is obvious, that the point of concurrence of the optic axes will be the centre of this field, in reſpect to which we eſtimate the direction of any other point as lying to the right or left, or above or below, &c. Or, conceiving this viſible ſurface as thrown out into diſtance and ſolidity, we may conſider the field of viſion to be divided into a right and a left half by a vertical plane, which dividing plane muſt evidently appear or be conſidered only as a perpendicular line. When the two eyes are uſed conjointly, this dividing plane will be the two optic planes appearing united; when one eye only is uſed, the vertical plane dividing the field of viſion into two equal parts, will be the optic plane of that eye which is uſed.

WE may obſerve, and the obſervation is of more conſequence than may at firſt appear,

pear, that there is no original feeling or immediate conſciouſneſs in the mind, by which it knows whether it ſees with one or the other eye. We may, from experience and a compariſon of circumſtances, be able to determine this, but not by any original ſenſation; and, indeed, there are many who would ſcarcely be able to pronounce whether they ſaw with one or with both eyes: and I was acquainted with a moſt reſpectable and well-informed perſon, who declared that one of her eyes had been deprived of its ſight ſome months before ſhe diſcovered her loſs. But ſince the viſible circumſtances attending the ſame object are different as ſeen by one or by the other eye, the judgment muſt of courſe be under the influence of ſuch circumſtances.

Suppose a cube to be placed in ſuch a ſituation, that one of its ſides, ſay the left, ſhould lie preciſely in the right optic plane, it would follow, that if the right eye only were uſed, this left ſide could not be ſeen, two ſides only of the cube would be viſible, either the upper or the lower, and that one fronting the eye; but if the object were viewed at the ſame time by the left eye, the left ſide of the cube would become viſible.

We may ſuppoſe another cube ſimilarly placed in the axis of the left eye, and the circumſtances would be the ſame.

Hence it appears, that when the two eyes are uſed, the field of viſion conſiſts of objects of which ſome are ſeen with both eyes, and others are ſeen only by one eye; and from this circumſtance there ariſes, a ſeeming increaſe of viſible ſpace, when the optic axes croſs each other. And hence alſo, it is obvious, that the field of viſion, as ſeen by each eye ſeparately, will be different; for, when the right eye only is uſed, the field of viſion muſt tend to the left, and when the left eye is uſed, it muſt;

for the ſame reaſon, incline to the right; and, therefore, when the two eyes are uſed conjointly with the axes inclined to each other, the field of viſion muſt be increaſed, being extended to the left by the right eye, and to the right by the left eye; and different fields of viſion muſt require different planes of partition.

A FIGURE will aſſiſt our conceptions of this matter.

LET AP and BP, *fig.* 5, be the optic axes croſſing each other in the point P, the eyes being ſuppoſed at A and B, and let PM be the common axis determined as in the former figures, biſecting the angle APB. Then if the line CD is drawn perpendicular to the axis AP, it is evident, that no point lying behind this line, or on the ſide oppoſite to that on which the axis lies, can poſſibly be projected on the eye at A. Therefore, this line CD may be conſidered as limiting the field of viſion of the eye at A, while the axis is directed to the point P: in the ſame manner, the line E F will limit the field of viſion of the right eye at B, and the point of interſection of theſe lines will, in this caſe, be in the common axis P M. Now it is evident, that the angle C M E or F M D made by the interſection of the limiting lines, is equal to the angle A P B, the inclination of the axes; and by drawing L G perpendicular to P M and biſecting the angles C M E and F M D, it appears that when the two eyes are uſed the meaſure of the whole range or field of viſion will be increaſed by the angles L M E and D M G, equal together to the inclination of the two optic axes.

When the right eye is uſed alone, the plane dividing the field of viſion will lie in line B P, and will be the right optic plane; when the left eye is uſed ſingly, the field of viſion will be divided by the left optic plane paſſing through the axis A P; but when the two eyes are uſed conjointly each optic axis becomes an object of ſight to the other eye reſpectively, thus interpoſing, as it were, new viſible ſpace; and the range or field of viſion, comprehending the angular ſpace EMD, muſt be divided by a plane paſſing through the line PM, which biſects that ſpace or range, and which will be the two optic planes apparently united and paſſing through this line *.

HENCE we may derive a reaſon why an object ſituated at the concurrence of the op-

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* IT may be neceſſary to remark here that I do not mean to advance the above as a general propoſition, that extends preciſely to every poſſible caſe of viſion: the caſe here conſidered is that of direct viſion, or of the general and ordinary uſe of the eyes. And my intention is only to convey a notion of the general principle which influences the ſeeming direction of an object as ſeen by one or the other eye, or by both together. In caſes of very oblique viſion the object to which the optic axes are directed is not conſidered as the centre of the field of viſion; but in general; the uſe of the right eye cauſes an object to appear more to the left, and the uſe of the left eye makes it tend to the right.

tic axes has an apparent motion, or appears to have a different place as ſeen alternately by the one or the other eye ſingly; for the field of viſion being in theſe caſes different, it muſt require a different centre or plane of partition; but the object at the concurrence of the axes muſt be in the centre in either caſe, and therefore the mind refers it to a different place, to the right or to the left, according to the eye which is uſed; and for the ſame reaſon it is referred to a middle ſituation when both eyes are uſed conjointly.

I AM fearful that a wiſh to be clear may render me tedious. It is, however, better to be a little prolix than obſcure; I ſhall, therefore, farther illuſtrate this matter by another *figure*.

LET A and B, *fig*. 6, again repreſent the eyes, and AP and BP the optic axes croſſing each other in P as before. Let C and

D be two objects in the left axis at equal diſtances on each ſide the point P, and E and F two other objects in the right axis at the ſame diſtances from the point P.

Now, if the left eye ſhould be uſed, the objects E and F would appear as lying one to the right and one to the left of the plane of partition; but the two objects C and D would appear to coincide with this plane. On the other hand, ſhould the right eye be uſed, the objects C and D would now appear to lie one to the right and one to the left of the dividing plane, and E and F would be the coinciding objects. Should both eyes be uſed together, D and F would be two right-hand objects; namely, D a right-hand object to the right eye, and F one to the left eye; and E and C would be the two left-hand objects, E being one to the left eye and C one to the right eye; and the dividing plane would now ſeem to lie in the direction P M.

With the apparatus already deſcribed, all this may be actually put to the proof of experiment with much eaſe. In this caſe, the point P ſituated at the concurrence of the axes will be reſpectively referred to three different places. When the left eye is uſed, it will be referred to the ſame place as the object D, with which it will appear to coincide. When the right eye is uſed, it will be referred to the ſame place as E for a ſimilar reaſon: and when both eyes are uſed, it will be referred by the mind to a place lying midway between the former two.*

Upon the principles now ſtated, we may be able ſatisfactorily to explain various phenomena of ſeeming direction from viſible circumſtances, without having recourſe to the ſtate of action in the muſcles which move the eyes. For inſtance, that while an optic axis retains the ſame real poſition, an object ſituated in it may ſeem to have a variety of different directions. If the right axis ſhould remain fixed, and the eyes be ſucceſſively directed to different points in it, the field of viſion, both eyes being uſed, muſt change with every ſucceſſive point to which the eyes are directed; if from a remote point to one that is nearer, ſo as to increaſe the inclination of the axes, the field of viſion, and conſequently its plane of partition, will tend towards the right, and the point where the axes croſs each other will be referred to a ſituation more towards the right, as being the apparent centre of the field of viſion. This may be rendered very plain by attending to the apparent circumſtances of a cube, as before mentioned, one ſide of which is ſuppoſed to be ſituated in the right optic plane: when ſeen with the right eye only, this ſide of the cube will lie in the plane which appears to divide the field of viſion; but when ſeen by both eyes the ſide before inviſible comes into view; and the effect in reſpect to the mind is preciſely the ſame as if the cube were to be removed to the right as to render the left ſide of it viſible; for, as was before obſerved, there being no original feeling by which we can diſtinguiſh that which is an object of ſight to one eye from what is an object of ſight to the other eye, the judgment and conception are influenced by the apparent circumſtances. The nearer the optic axes approach to paralleliſm, or the more remote the cube is from the eye, the leſs the field of viſion tends to the right; and in an increaſe of the inclination of the axis, the left ſide of the cube, having a more direct appearance in reſpect to the left eye, muſt appear more to the right.

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* Beſides the four objects which are in this caſe ſeen, of which two appear on the right and two on the left ſide of the plane of partition, all the four, C, D, E, and F, will alſo be ſeen united in the line PM, or as lying in the plane of partition; the firſt are ſeen two by one eye and two by the other; the laſt are ſeen each by both eyes together.

AND that the judgment reſpecting direction is, in this caſe, influenced by the *viſible circumſtances*, and not by the ſtate of action exiſting in the muſcles, is evident from the Second and Third Experiments; for, when the objects were ſeen by the right eye only, the ſight of the other eye being intercepted by the interpoſition of the black card (a circumſtance which could not prevent its motions from correſponding with thoſe of the other eye) the direction of the points O and P* remained unchanged, whether the eyes were directed to one or to the other. Here then we have an inſtance of apparent direction remaining the ſame, while the ſtate of action in the muſcles changes; on the other hand, while the eyes continued to be directed to one of the objects, as O, it appeared to have a different direction as ſeen by one eye ſingly, or by both at the ſame time; which is an inſtance of change of apparent direction while the ſtate of action in the muſcles remained the ſame. The real circumſtance which influenced the mind in the ſeeming direction being this, that when the left eye was uncovered, the ſpace O P of the right axis, which was before inviſible to the right eye, now became an object of ſight interpoſed between O and P, ſimilar to the ſide of the cube.

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* See *fig.* 3.

And upon the ſame principles is to be explained the reaſon why, in different real poſitions of the optic axes an object ſituated in them may appear to have but one and the ſame direction. For, when the eyes are ſucceſſively directed to different points, all lying in a line perpendicular to, and biſecting, the viſual baſe, it is evident, that while both eyes are uſed, the field of viſion will in each caſe be divided by the ſame plane; for, notwithſtanding the extent of the field, or the range of ſight, is contracted as the eyes are directed to the more remote points, and the axes approach to paralleliſm, yet the contraction being equal on the right and on the left ſide, the plane of diviſion muſt, throughout, remain fixed; and the optic axes appearing to be united in this plane, it follows, that their apparent direction, or that of an object ſituated in them, would remain the ſame in various changes of their real poſition. But if one eye only ſhould be uſed, and ſucceſſively directed to the ſeveral points, there would in each caſe be a different field of viſion, each lying to the right of the other, and conſequently requiring a different plane of diviſion, and different centre, and the axis of the eye would then have an apparent motion to the right correſponding with its real motion: all which appears clearly from the Fourth Experiment.

And here again, we have an inſtance of a ſeeming change of direction, while the ſtate of action remains unaltered; for, while the two eyes are held directed to any one of the points, its apparent ſituation varies as one or both eyes are uſed.

SUCH are the obſervations which have occurred to me in examining the theory of viſible direction laid down by Dr. Wells. In the preceding ſection my intention was to point out that, even admitting the facts ſtated in this theory, it would not neceſſarily follow, that ſingle viſion was the *conſequence* of ſuch a law of direction; for, direction in a line from the eye being an acquired notion or conception, and the ſingle appearance an actual matter of ſight, it would ſeem more reaſonable to conſider the apparent union of the points where the optic axes terminate on the retina as the original law, and from thence to derive the law of direction; for, if the two points are united into one by ſome original ſenſation or impreſſion, the re-projection or throwing out of this united point into diſtance can only conſtitute one line. However, in the preſent ſection, the experiments which are brought forward prove, that the point of interſection of the optic axes has a different ſeeming direction as ſeen by one or by the other eye, or by both at a time; which reduces the matter to a certainty; ſince, in order that the ſingle appearance ſhould be *cauſed* by a law of viſible direction, it is neceſſary that this law ſhould affect each eye when uſed ſingly, in the ſame manner as when uſed in conjunction with the other; and ſuch Dr. Wells maintains to be the caſe; but all the experiments here mentioned, and I have tried them over and over again, are inconſiſtent with this opinion. But, ſince an object, if it appear ſingle to the two eyes, muſt, at the time it is ſo ſeen, appear to each eye to be in the ſame place; that is, ſince one viſible object can only have one viſible place at one time, and ſince this place is not that which it has when ſeen by either eye ſingly, we may ſafely conclude, that the apparent place of the object when ſeen by both eyes is dependent on the circumſtance of its being ſeen ſingle.

In canvaſſing the opinion of Dr. Wells, I have only made uſe of that liberty to which all have a claim in treating philoſophical ſubjects; and I truſt, that while producing a direct oppoſite opinion, I have not, any where, expreſſed myſelf in terms which can with reaſon give the ſlighteſt degree of offence to that Writer.

It remains to ſtate the evidence we have for conſidering the united appearance of objects ſeen by both eyes to be the conſequence of an united impreſſion or ſenſation; this will be the ſubject of the following Section*.

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* Before I proceed to the next Section I wiſh to make a few remarks on a certain phenomenon of viſion which is mentioned by Dr. Wells in a note in the 105th page of his Eſſay, for which I have not been able to find a place before, as the principles concerned here are very different from thoſe we have been conſidering.

The experiment is this: If a ſmall hole be made in a card and held near to the eye and ſome opaque body, as a needle, be paſſed between the eye and the hole, there will be ſeen two objects, one the needle itſelf paſſing in one direction over the hole, the other a ſhadow of the needle paſſing in a cona contrary direction, and ſeeming to be on the other ſide of the card.

I do not enter on the explanation of this phenomenon with a view to controvert the principles on which Dr. Wells has accounted for this appearance, which, as he juſtly ſays, lie on the very ſurface of optical knowledge; but the account he has given of this experiment, and of that of Mr. le Cat, which gave riſe to the note, appears to me to be imperfect, as it kept me in doubt, while reading it, whether the ſhadow as it is called, was the only object which was ſeen in the experiment. The ſolution of Mr. Harris hinted at in the note, which is all I know of it, is certainly juſt, "that it is not "the needle but its ſhadow on the other ſide which is ſeen." As the experiment may be new to ſome who have not been in the habit of ſtudying this ſubject, I have introduced this account in order to ſhew how readily we may fall on the true explanation of ſuch phenomena by having immediate recourſe to the projections on the retinæ.

Let AB, *fig.* 7, repreſent an eye, and the point P the hole in the card, which, if held up againſt a ſtrong light, may be conſidered as a luminous point. Let R and L be any two diſtinct, external, or tangible objects, namely, R one on the right hand, and L one on the left, whoſe projections on the retina will be at *r* and *l* reſpectively, then we muſt conſider *r* as the right ſide on the retina, and *l* as the left, and a figure or body paſſing over the retina in the direction from *r* to *l*, will appear to move in that direction which we call from right to left. Now, ſuppoſe the card with the hole in it to be held ſo near the eye that the accurate projection of the hole or point P ſhall fall beyond the retina at *p*; the pencil of rays PAB, which iſſue from the hole and cover the pupil, will be diffuſed over a part of the retina in a ſmall circle repreſented by *fg*; now that half of this ſmall luminous circle which lies on the retina towards *l* will appear as being the left half, and is formed by rays which enter the pupil on the ſide B, or on the right ſide in reſpect to the external object R, and that half which lies on the ſide towards *r* will appear as the right half, and is formed by rays entering the pupil on the ſide A, or the left in reſpect to the object L. Suppoſe the needle to move along the line C D in the direction from C to D, or from right to left, reſpecting the external object, then will the projection paſs over the retina in the direction from *r* to *l*, which is from right to left on the retina; but when it comes to F it will begin to intercept the rays which form the ſide of the luminous circle on the retina towards *l*, that is the left ſide, and muſt therefore efface part of the left ſide of the circle, appearing as a ſhadow, while the needle itſelf will appear on the right ſide: and ſo as the needle proceeds from right to left it will ſucceſſively intercept the rays which form the circle, in the direction of *l* to *r* or left to right, contrary to the motion of the needle, and appearing as a ſhadow. When the needle arrives at the central ray, the projection of the needle and the ſhadow become one object, the projection of the needle itſelf in that ſituation effacing the central part of the luminous circle; as the needle proceeds to the left, the right ſide of the circle becomes obſcured by the interception of the rays which enter on the left ſide of the pupil, and which form the right half of the circle.

And the ſhadow has the appearance of an object paſſing beyond the card, which I ſuppoſe is owing to the circumſtance of its being viſible only while paſſing over the diameter of the circle or of the hole in the card.

The ſame principles would apply to a motion in a vertical direction, and cauſe the inverted appearance of the ſhadow.

SECTION VI.

Arguments and Experiments tending to prove that Single Viſion is the Conſequence of an united Senſation.*

I AM now to ſtate the evidence which tends to prove that the eyes are endowed with ſome original property, in conſequence of which the impreſſion made on a certain point of one retina is united with the impreſſion made on a certain point of the other retina; and that the united appearance of the projections in a certain ſituation of the eye ariſes from this united ſenſation.

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* The Author knows little of what may have been already written on this part of his ſubject. M. du Tour made ſome experiments ſimilar to what are here mentioned, but the conſequence he drew from them was very different from what is here advanced.

However deciſive this evidence may be to my own mind, I do not pretend that it amounts to abſolute demonſtration; but it appears to me fully ſufficient to render the propoſition highly probable, where the mind is not under the influence of a previous attachment to ſome different theory.

The firſt argument to be produced is founded on the analogy of nature. It is a fact well-known to anatomiſts, that in the human ſpecies the optic nerves unite in the *ſella turcica* before they enter the brain: and a ſimilar union takes place in various other ſpecies of animals. But, if I am rightly informed, there are ſome ſpecies of animals whoſe eyes are ſo ſituated as to look to oppoſite ſides, and conſequently not to ſee the ſame object at the ſame time with both eyes, in which ſuch a junction does not take place. Without inquiring into the manner in which this union is formed, we may ſuppoſe that nature had ſome purpoſe to anſwer by it; and it ſeems probable that it may have ſome relation to ſingle viſion, and may cauſe this by uniting the ſenſations. The circumſtance, taken ſingly, may not be thought of much conſequence, nor do I lay much ſtreſs on it; but it ſerves to corroborate when united with other facts*.

ANOTHER circumſtance I have to mention, which makes in favour of the poſition, is what happened to the young gentleman couched by Mr. Cheſelden. It appears, that on firſt receiving his ſight he thought that all objects *touched his eyes*; that is, he ſaw the projections on his retinæ, without aſſociating with his viſible perceptions the conception of diſtance or of direction in a line from the eye; but it does not appear that he ever ſaw the objects he looked at double. This proves, as far as one inſtance can go, that ſingle viſion is original, and that it does not depend upon any law of viſible direction.

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* AN ample field of reſearch ſeems to lie open to the anatomiſt reſpecting the brain, of which, from the peculiar nature of its ſubſtance, our knowledge is extremely limited. But I ſhould hope, that in the preſent highly-improved ſtate of every art, means might be deviſed for developing the hitherto inexplicable folds of this moſt curious ſubſtance, and for explaining the nature and the mode of its very important functions.

I PROCEED now to produce ſome ſimple experiments, which favour the notion of an united ſenſation.

EXPERIMENT I.

THEY who are accuſtomed to uſe ſpectacles know, that the two rings appear to unite and to form one circle. Into the rings of a pair of common ſpectacles let two pieces of ſtained glaſs of different colours be fixed; and if theſe ſpectacles ſhould be worn in the common manner, it is evident, that over one of the retinæ will be diffuſed rays which excite one colour, and over the other retina will be diffuſed rays which excite ſome other colour; and the conſequence will be, that neither colour will be ſingly perceptible, but that ſome intermediate colour will be ſeen. If the eyes ſhould be alternately cloſed, ſo as to exhibit the two colours ſingly, one ſucceeding the other, and immediately after both eyes ſhould be kept open, the intermediate colour will be made very perceptible. This experiment alone would be perfectly deciſive to my mind; but it will not, perhaps, produce the ſame degree of conviction in others, particularly in ſuch as may have admitted ſome theory different from that now propoſed.

BUT let us reflect on the true nature of colour, and on the true nature of viſion.

Colour we know to be a ſenſation excited by the action of light; but here we have rays acting on either retina, whoſe ſingle effect would be to produce ſome colour which in this caſe is not perceptible. What then is that intermediate colour which we ſee, and how does it ariſe? It is an effect, and requires ſome cauſe; and it is an effect which can only be produced by the action of rays of light on the optic nerves; it therefore muſt be the joint effect of the rays acting on the two retinæ, or an united ſenſation.

This experiment may be varied by uſing, inſtead of ſpectacles, two tubes with the inſides blacked, and differently-coloured glaſſes fixed at the extremities fartheſt from the eye. When ſuch tubes are applied to the eyes, it is evident that if the axis of each tube coincides with the axis of each eye reſpectively, the apertures at the ends will be projected on the terminations of the optic axes, or on ſimilar points of the retinæ; but if one of the tubes ſhould be ſo moved, that its axis ſhould no longer coincide with the optic axis, the aperture at the end would be projected on ſome part of the retina diſſimilar from that of the other. In the firſt caſe the two tubes, as with a binocular teleſcope, appear to coincide and to form one, and the aperture will appear to be of ſome intermediate colour, as in the inſtance of ſpectacles; in the latter caſe, the two tubes will appear ſeparate and diſtinct, as will alſo the colours of the apertures. But the tubes may be held in ſuch an intermediate ſituation, as that part of the apertures ſhall fall on correſponding points, and part on points which do not correſpond; in which caſe the two colours will appear diſtinct on the ſeparate parts of the apertures, and the third or intermediate colour will appear on that part of the aperture which is united, or which falls on the correſponding points of the retinæ.

In making theſe experiments ſome circumſtances are to be noticed, a want of attention to which, might lead ſome to ſuppoſe that the experiments did not anſwer.

What is generally underſtood by deepneſs of colour, is not occaſioned by the denſity of the rays, nor by the intenſity of their action, but proceeds from their rarity. A few rays of any colour diffuſed over a part of the retina would excite the notion of a dark colour; for deepneſs of colour approaches to blackneſs, which is the privation of colour or ſenſation. If, therefore, we look through a glaſs deeply ſtained with any colour with one eye, and ſhould either not apply any, or only ſome light-coloured glaſs to the other eye, it is not to be ſuppoſed, that the general appearance will be that which might be compounded of a deep colour mixed with white or with ſome light colour; for the eye which ſees through a dark glaſs will be affected only with a weak ſenſation, which conſequently can produce but little effect on the ſenſation of the other eye; and if the ſtained glaſs ſhould be ſtill deeper, we might not be able to ſee through it at all; while the ſenſation of the other eye would remain perfect in the ſame manner as if one eye was cloſed.

HENCE, when we apply to the eyes glaſſes ſtained with different colours, we are not to expect that the colour compounded of the two will have the ſame appearance as if we looked through both glaſſes with one eye. If a blue and a yellow glaſs are placed one before the other, and applied to one eye, the appearance will be that of a full green; but if the ſame glaſſes ſhould be applied, one before each eye, as in the experiment of the ſpectacles or tubes, the colour will be a green diluted with much white light, or a pale green; for when the glaſſes are placed one before the other, the two in this poſition intercept much more light than when they are ſeparate; and this for a reaſon which muſt be obvious to all who are acquainted with optics.

And therefore in the above experiments it is not neceſſary that the intermediate colour be ſuch as might previouſly be expected from a mixture of the two colours of the glaſſes; it is ſufficient for the concluſion we draw, that any colour ſhould be ſeen different from that of either of the glaſſes ſingly *.

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* In a note to the "Eſſay on Single Viſion with Two "Eyes," page 45, Dr. Wells obſerves, "that in all his ex-"periments of ſeeing two differently-coloured objects, one "with each eye, with the eyes ſo ſituated as to cauſe the ob-"jects to appear united, the two objects, notwithſtanding "their apparent union, appeared each in its proper colour; "as a red appearing as it were through a tranſparent green, "and a green through a tranſparent red, &c."

When I have attempted to ſee two objects of different colours, one in the axis of each eye, I acknowledge that the reſult has not been agreeable to my expectation; for at times I ſaw only one of the objects, at times only the other; but when I caught the two objects united, there certainly was a colour ſeen diſtinct from that of either ſingly, though not

EXPERIMENT II.

I PROVIDED a piece of paſteboard of about one foot in breadth and two in length; one end I cut ſo as to adapt it to the profile of my face, in ſuch manner, that when applied to it in a vertical poſition perpendicular to the plane of the face, the rays which came to one eye were intercepted from the other. I then placed a ſheet of white paper perpendicularly againſt a wall to which a ſtrong

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not that which might have been previouſly expected from the compoſition of the two. And I apprehend that Dr. Wells, in the experiment he mentions, has been apt to confound imagination with ſenſe; for I conceive it to be impoſſible to ſee one colour through another.

WHEN we look at an object of known colour through a ſtained glaſs of any other colour, we are apt to think we perceive two colours at the ſame time; but it is probable that in this caſe the imagination is employed at the ſame time with ſenſation; that is, from knowing the colour of the object we conceive it to be of one colour, while we ſee it of another; and I apprehend it may be laid down as a maxim in viſion that the ſame individual point cannot appear at the ſame time to have two different colours. This is not a propoſition to be proved by argument; it is a firſt principle; if we attempt to conceive the contrary, we find it impoſſible.

ſtrong light was admitted, and drew a line on the paper dividing it into two parts, on of which was ſeen by the right eye, and the other by the left; but neither of them could be ſeen by both eyes together, the diſtance being about three feet. While looking ſteadily at the paper with my right eye, I applied a piece of ſtained glaſs to the left eye, when immediately a light tint of the colour, became ſenſibly ſpread over that ſide of the white paper which was ſeen by the right eye only. In making this experiment I found, that if dark ſtained glaſſes were uſed, the ſenſation of the eye to which they were applied was too weak to affect the ſtrong ſenſation of white light on the other eye; but when I uſed a glaſs moderately ſtained, the diffuſion of the light tint was very obvious.

This experiment appears to me equally with the former to afford a deciſive proof that the ſenſation of one eye is affected by or blended with that of the other eye; for how otherwiſe can we account for an object appearing coloured by the application of a ſtained glaſs to the eye by which that object cannot be ſeen.

EXPERIMENT III.

Take one of the tubes above-mentioned, and cloſing one eye apply it to the other, not cloſe, but at the diſtance of three or four inches, and look at the wall or wainſcoat, or at any plane ſurface of a light colour; and the object or ſurface, as ſeen through the tube, will appear of the ſame colour and brightneſs as that part ſeen on the outſide of the tube. Next, bring the tube cloſe to the eye, the other remaining cloſed, and the object ſeen through the tube will appear ſomewhat brighter than before; and this I conceive to be owing to the contraſt with the blacked inſide of the tube. Now, open the other eye, and, looking at the ſurface or object with both eyes at the ſame time, the ſuperior brightneſs of the part ſeen through the tube will become much more ſenſible. In this ſituation, the part of the ſurface ſeen through the tube is ſeen by both eyes, whereas the other part of it ſeen without the tube is ſeen only by one eye; and the remarkable ſuperior brightneſs of this part ſeen through the tube muſt, as I conceive, be owing to the circumſtance of its being ſeen by both eyes; that is, there is a double ſenſation of this part, and only a ſingle ſenſation of the other part.

EXPERIMENT IV.

THE experiment I am now about to mention is beſt made by candle-light; and I have made uſe of one of the patent lamps as yielding a very ſtrong light. It is a well-known fact, that if the eyes are ſuddenly cloſed, after having been for ſome time ſteadily directed to ſome bright object, a coloured ſpectrum will become perceptible. The nature of theſe ſpectra and the variations in colour to which they are ſubject, were, ſome time ſince, made the ſubject of a very ingenious inveſtigation by Dr. Darwin. At preſent we have only to conſider the general appearance independent of any particular colour.

Let the eyes be held ſteadily fixed on one of the above-mentioned lamps for a minute or two, after which, on ſuddenly cloſing them, a coloured ſpectrum will be ſeen. If any doubt ſhould be entertained whether or not the two eyes are equally affected, in this caſe it may be clearly aſcertained by looking with one alternately, the other being cloſed, at a ſheet of white paper, when in either caſe a dark ſpot or ſpectrum will appear on the face of it.

I MENTION this circumſtance merely to remove any doubt of each eye being equally affected; but our experiment requires the eyes to be cloſed, when a ſingle coloured ſpot or ſpectrum will become plainly perceptible. I requeſt the reader's particular attention to the circumſtances of this experiment: the ſpectrum appears ſingle, and no forced diſtortion of either eye or of both at the ſame time can affect the unity of the appearance. But what is this appearance? it is merely a matter of ſenſation, the central part of each eye is ſtrongly affected by the late impreſſion of the light on it. Here is no external object ſeen or imagined, and conſequently nothing reſpecting direction from the eye or external place can be concerned in this experiment; the whole relates to ſenſation; but as each eye is equally affected, the ſenſation muſt be united, otherwiſe the ſpectra would appear diſtinct; we have not even a conſciouſneſs of both eyes being concerned, and the method above-mentioned is neceſſary to determine whether one eye only, or both are affected.

If the eyes ſhould be directed to ſome diſtant object, and the lamp ſhould be placed before them, at the diſtance of about three feet, the projections of the lamp will be found on diſſimilar points of the retinæ, and two diſtinct ſpectra will be perceptible.

THE foregoing experiments, taken collectively, appear to me fully ſufficient to eſtabliſh the fact, that an impreſſion or ſenſation made on a certain point of one retina is united, by ſome original law of the conſtitution, with the impreſſion or ſenſation made on a certain correſponding point of the other retina.

The intermediate colour perceived, when glaſſes differently ſtained are applied to the two eyes, can only be accounted for, by admitting ſuch an union of the ſenſation. Over each eye are diffuſed rays, exciting ſome colour, which, ſo long as both eyes remain open, is not perceptible; the colour being ſome intermediate tint; but on cloſing either eye, ſome colour different from this immediately becomes viſible, without any alteration taking place in the eye by which ſuch colour is ſeen. I can conceive nothing more concluſive. But from this fact if admitted, the ſingle appearance of all objects naturally reſults.

The appropriate ſenſation of the optic nerve is colour. In the laſt experiment of the ſpectrum, there is no external object viſible or tangible immediately concerned, nor any rays of light in preſent action; the ſpectrum is a durable impreſſion cauſed by the ſtrong light lately ſeen; but this impreſſion is made manifeſt by the perception of ſome colour, and this being excited,

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the perception of extenſion follows as a natural conſequence; the ſpectrum itſelf is an extended and figured object.

When there are two ſimilar projections, one on each retina and on that point of the retinæ where the optic axes terminate, or, according to the common notion, when we look at an object, the ſenſation is united preciſely as in the caſe of the ſpectrum; when theſe projections are of diſſimilar objects the two will appear mingled together in a confuſed manner *. But it is clear from the expe-

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* When experiments have been made for ſeeing two differently-coloured objects united, by placing them one in the axis of each eye, the reſult has generally been, that at one time one only was ſeen, at another time the other, and at intervals the two have appeared confuſedly united. But we ſhould recollect, that in this experiment it is neceſſary, in order to bring the objects on thoſe points of the retina where the optic axes terminate, that the ſtate of the eyes, or at leaſt of one of them, ſhould be adjuſted for ſome diſtance different from that of the object; and if, as has been ſuppoſed, and as I believe is true, there is a change of the refractive ſtate of the eye with every change of diſtance in the object, it muſt follow,

experiment of the ſpectrum, that neither direction from the eye, nor external place, nor poſition, have any concern in cauſing the unity of the appearance; theſe are merely relative and ſecondary notions; viſible extenſion is a neceſſary adjunct or concomitant of colour, and the union of the ſenſation is in fact the union of the extenſion, with its modifications of figure, poſition, &c.

However convincing this ſolution of the queſtion concerning ſingle viſion may be to my own mind, I conceive it to be very probable that it may not appear equally ſo to others. But if it ſhould not be admitted, it muſt, I think, be allowed, that we have no other more ſatisfactory, and that the

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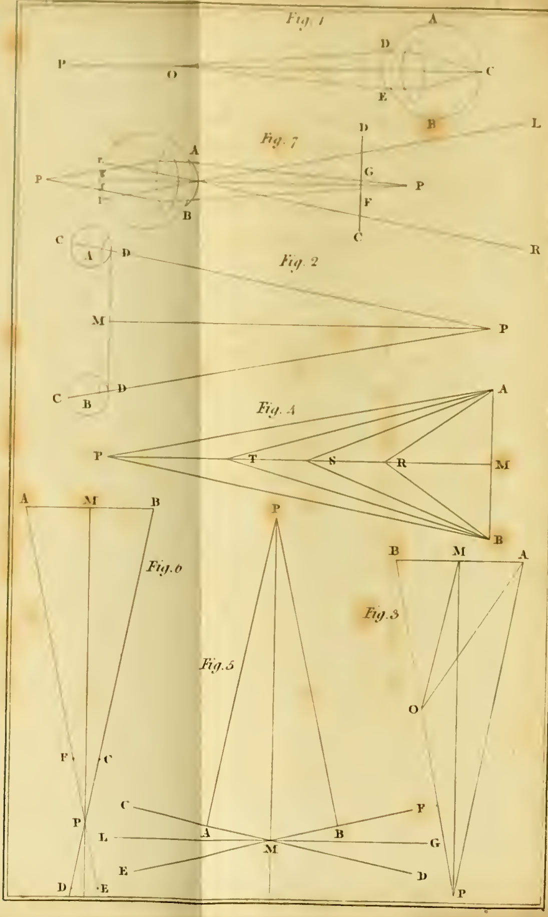
follow, that the ſenſation of one or both eyes in this experiment muſt be imperfect, becauſe the refractive ſtate of the eye cannot be adapted to the diſtance of the object ſeen; and to this cauſe we are probably to attribute the uncertainty and irregularity of this experiment; the ſenſation of one eye prevailing at one time, at another time that of the other.

queſtion ſtill lies open to future reſearch; and I ſhould hope that what has now been ſaid, may at leaſt have the effect of promoting further inveſtigation, and of ſuggeſting other experiments which may lead to a more perfect deciſion.

It was at firſt my intention to have conſidered ſome other circumſtances relating to viſion, particularly reſpecting viſible poſition as an original ſuggeſtion; but I fear that the reader may by this time be tired of the ſubject, and I ſhall proceed no further at preſent.

THE END.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